JPRS L/10036

7 October 1931

Worldwide Report

NUCLEAR DEVELOPMENT AND PROLIFERATION

(FOUO 12/81)

Selections on CSSR Nuclear Power Construction, Equipment

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

FOR OFFICIAL USE ONLY

JPRS L/10036

7 October 1981

WORLDWIDE REPORT

NUCLEAR DEVELOPMENT AND PROLIFERATION

(FOUO 12/81)

SELECTIONS ON CSSR NUCLEAR POWER CONSTRUCTION, EQUIPMENT

CONTENTS

SIGNIFICANCE OF V-1 NUCLEAR POWER STATION DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 p 121

[Article by Ladislav Blazek, CSSR Deputy Ministry of Fuels and Power: "The V-1 Nuclear Power Station: The First Component of the Nuclear Power Complex"]

[Text] The program for providing fuels and energy is of fundamental importance for the Czechoslovak national economy and for raising the standard of living in the CSSR. Thanks to the concern of the Czechoslovak Communist Party and to guidance by the state, in the past 30 years the output of black coal has increased by 70 percent and that of brown coal by 4 times, production of electrical energy has increased by 9 times and the use of lighting gas has increased from less than 0.4 billion cubic meters a year in 1948 to a current figure of 3.9 billion cubic meters a year, in addition to 9.1 billion cubic meters of natural gas.

Nonetheless, Czechloslovakia too must over come the consequences of the world energy crisis. This primarily involves slowing the inflation of oil prices and faster replacement of liquid fuels, even though Czechoslovakia has not changed over to liquid fuel on so large a scale as in the majority of industrially developed countries. In 1980, liquid fuels accounted for 25.4 percent and solid fuels for 61 percent of consumption.

But the gap between increasing fuel and energy consumption and the possibilities for obtaining resources has widened so much that we are being forced to take systematic measures to redress the balance, not only in energy production and the extraction and import of fuels, but in consumption as well.

As regards resources, i.e. development of the fuel and energy base, the program is based on close coordination, economic cooperation and integration with the Soviet Union and on utilization of the CEMA countries' energy resources, but with concurrent maximum possible development of our own resources. Immense projects for through pipelines to carry natural gas from the remote Siberian regions of the USSR are being carried out and in addition a large-scale program for construction of a nuclear power complex in Czechoslovakia is being implemented.

The nuclear power complex in Czechoslovakia is based on scientific plans, physical designs, production technology designs and experience obtained in the Soviet Union. The agreement signed on 30 April 1970 between the Soviet Union and Czechoslovak governments regarding cooperation in the construction of two nuclear power stations using pressurized water-cooled reactors of the VVER-440 type enabled Czechoslovakia to rapidly construct nuclear plants which were reliable and had been tested in operation.

The agreement was also based on the supply capabilities of the Czechoslovak power equipment industry: other than the reactor and the directly associated reactor control system, Czechoslovak equipment was to be used. The technical design for the power station was worked out jointly by Soviet and Czechoslovak designers to combine Soviet and Czechoslovak equipment.

Construction began in 1974 and the first unit was started up on 17 December 1978 following extensive physical trials and tests. Test operation was begun on 31 March 1979. The second unit was phased in for the first time on 26 March 1980 and put into trial operation on 26 May 1980.

Trial operation of the power station demonstrated that the reactor, from the Izhorskiy Zavod enterprise in Leningrad, and the Skoda turbogenerators, worked reliably, safely and effectively.

During 1979 and 1980 the power plant's performance was gradually improved and the design characteristics were gradually achieved and surpassed. The limiting factor in this process was problems with the coolant water circuit and its quality.

The V-1 nuclear power station has had an important effect on the electrical energy balance. Its reliable, constant output and small amount of downtime have made it a first-rate, basic energy source. In 1980 it produced 4,523 billion kilowatt-hours of electrical energy.

This confirms the validity of the conclusion that nuclear power stations should provide for all increases in energy consumption starting in 1983, since there is no possibility for increasing the output of coal-fired stations before 1988. Even though in the past it was always risky to base the expansion of the power industry on a single type of power production, the preconditions for focusing on nuclear power plants of the Voronezh type are so positive that the idea can be considered not only progressive but reliable as well.

By 1986 a total of six additional units are to be built at Jaslovske Bohunice and Dukovany, and according to estimates from many quarters, by 1990 nuclear power stations will reach a total output of 7,280 MW. This would mean that nuclear power stations were supplying a third of electrical power consumption.

However, the program for construction of a nuclear power complex is not only of fundamental importance for energy, but in addition is a stimulus for a number of production sectors, for technical development and for management of the economy.

By its nature, its necessitates mastery of new production processes and new quality control and testing procedures. The considerable demand for concentration of capacities will pose new tasks in power plant construction.

All of these factors will also require higher quality personnel with not only thorough knowledge of their specialties, but with a real sense for the utilization of new findings from a wide range of sciences. In addition they must be people with a refined humanity and a lofty consciousness, who are devoted to socialism.

Thus the program for construction of a nuclear power complex has not only an immense economic significance, but social and political significance as well.

As indicated by the experience with construction of the V-1 nuclear power station, and now with additional nuclear power stations, the Czechoslovak industrial base has created the material, production, technical, organizational and manpower conditions for successful accomplishment of the program, even while many rough spots must be traversed.

Experience indicates that mastery of the program will depend primarily on utilization of the principles of design management, characterized by the use of network analysis and the simulation and modeling approaches, will make it possible to plan the activity of all program participants in advance in such a way that the individual stages in the activity will follow one another smoothly or will interlock with each other. Management of this type is the best expression of a systematically organized programmatic design.

It is self-evident that both the set of economic instruments and the methods of direct management must be correspondingly improved as they apply to the collectives.

This entails considerably strengthening the skills, authority and responsibility of the direct participants in the construction work and also equipping them in such a way that management is made considerably more flexible. This means that a strong "construction project leadership" must be created for every construction project and provided with extensive sources of information not only on the course of construction itself but also on the status of production in the subcontractor production enterprises, so that they can make a timely choice of optimal day-to-day approaches. Coordination of all participants in the construction work must be developed at a high level. Accordingly, "operational management groups" must be organized within the "construction project leadership" and "coordination groups" must be created at critical facilities. This will insure interdisciplinary accomplishment of the critical tasks in the construction work.

Experience with the construction of the V-1 power plant has demonstrated the critical importance of Soviet specialists' work in the construction of Czechoslovak nuclear power stations. Their assistance and their technical and organizational experience are major facotrs in solving complex problems. Their inclusion in international brigades creates the conditions for mastering especially complex tasks in record time.

Thus, for all construction participants from the designer to the operator, from the smallest worker collectives to the top management, the V-1 power station has become a school of advanced experience which will be used in the further construction and operation of nuclear power plants.

8480
CSO: 5100/3019

V-1 POWER STATION PLANNING DESIGN PROCESS DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 pp 122-126

[Article by Jiri Holub, Energoprojekt Praha: "The Planning and Technical Design of the V-1 Power Station"]

[Text] This article provides information on the main questions associated with provision of planning documentation for the V-1 nuclear power station in Jaslovske Bohunice, which was built in Czechoslovakia with the cooperation with Soviet specialists. It also describes the technical design of this power station.

Work associated with a reevaluation of the program for construction of nuclear power stations was concluded in Czechoslovakia at the end of 1969. It was decided that in the upcoming period nuclear power stations based on the VVER type of reactor with individual reactor capacities of 440 MWe, which had been developed and built in the Soviet Union and thereafter successfully put into operation as Units 3 and 4 of the Novovoronezh Nuclear Power Station, would be built in Czechoslovakia.

Preparations for construction of nuclear power stations of this type were begun in Czechoslovakia in 1969 on the basis of technical documentation provided to the Czechoslovak side following preliminary agreements. Talks with the Soviet Union on forms of cooperation in working out the planning documentation, deliveries of process equipment, and other activities by the Soviet organizations which were necessary for the construction and startup of these nuclear power stations, were under way concurrently. Basic discussions between the planning organizations of both sides concerning Czechoslovak provision of part of the process equipment were also held in 1969. In these discussions, the Czechoslovak side undertook to provide a substantial share of the deliveries, particularly for the secondary section of the power station.

The principles of cooperation in the construction of the first two nuclear power stations of this type in Czechoslovakia were laid down in an agreement between the CSSR and USSR Governments, which was signed in April 1970. Subsequently, CSSR State Decree No 195 was issued on 27 August 1970, specifying the basic conditions for the construction of the first of these nuclear power stations. In particular it designed the investor organization, the functions of Energoprojekt [power station planning organization], the supplier system including two general contractors, and the deadlines for commissioning of the individual units.

These documents made it possible to proceed to design preparation for the first commercial Czechoslovak nuclear power station, which was to have a total capacity of 880 MWe (two units, each with one V-230 reactor), and which received the name of "V-1 Nuclear Power Station, Jaslovske Bohunice," henceforth abbreviated JE V-1.

The preplanning documentation was developed before issuance of the documents mentioned above, and a construction site was chosen in cooperation with Soviet specialists. Finalization of the preplanning documentation and of the work associated with provision of the design documentation began after issuance of State Decree No 195/70; work in these areas had begun before the approval of the Planning Assignment. In addition, we should note that the enactment of this state decree was not based on the usual norms for capital construction; accordingly it signaled the adoption of a number of extraordinary approaches, which had to be agreed upon among the construction participants throughout the construction process.

In giving an overall evaluation of the planning work for the JE V-1, we must stress the decisive role of the Soviet Union and its specialists. The Soviet Union is the originator of the technical concept for this nuclear power station, which includes all the results of demanding, prolonged scientific, research, design, production and planning work and the practical experience obtained by Soviet specialists in the construction of their own nuclear devices and nuclear power equipment.

In working out the planning documentation, Energoprojekt cooperated closely with the Soviet design organization Teploelektroprojekt, and particularly with LOTEP, its division in Leningrad. As part of this cooperation, the preplanning documentation, including selection of a construction site, was worked out, as was the planning documentation itself; for the latter, LOTEP provided the technical plan and the construction and equipment installation performance plans for the critical power station facilities. In addition, Soviet specialists provided the Czechoslovak designers with running technical consultations during the development of the plan and the performance of the construction.

Provision of the planning documentation, the provision of consultations and other activities associated with the planning work were contracted from the Soviet side by Energoprojekt through the Foreign Trade Organization Skodaexport Praha (SEX).

The technical and economic part of the planning assignment for the JE V-1 was developed by Energoprojekt and handed over in October 1970 to the investor organization, which then assigned all of the planning work. The assignment of planning work developed in this manner was approved by FMPE [Federal Ministry of Fuels and Energy] on 3 December 1971 after discussions with the Soviet side.

Planning Documentation for the First Stage

This documentation was developed in cooperation with the Soviet side on the basis of the technical plan provided by the Soviet Union, which also included the assignments for the work to be carried out by the Czechoslovak side, the agreed-upon site layout, and coordination of all installations and equipment in the enclosed part of the power station site.

Energoprojekt issued the "Overall Plan" (SPR), which was worked out in accordance with FMTIR [Federal Ministry for Technical and Investment Development] Notice No 107/66Sb, except for the technical sections, which were directly documented by the Soviet side in its technical plan and which had been included in this Overall Plan as part of the Soviet technical plan.

With certain exceptions, the technical plan supplied by the Soviet Union was developed in accordance with Soviet regulations and technical standards and on the basis of technical data provided by Czechoslovakia for the secondary section. This technical plan was handed over to Czechoslovakia in March-May 1972 and approved by a joint Czechoslovak-Soviet evaluation board in June 1972.

The plan for the first stage of the project, which was included in the Overall Plan (contents as described above), was given to the investor organization in September 1972.

As a result of the new division of power plant equipment supply between the Soviet and Czechoslovak side and certain changes in the data for the Czechoslovak equipment, part of this SPR documentation was revised in September 1973. In addition, in 1973 the construction organization plan (POV) was reworked, the Overall Plan was refined, and certain parts of the Soviet technical plan were revised in accordance with a Czechoslovak-Soviet evaluation of the technical plan and a statement of additional requirements by the investor organization. The SPR documentation with these changes was approved as a whole by the investor organization in February 1974. An annex to this duly approved SPR, detailing the division of the process equipment into operating sets, and including an annex to the POV, was developed in May 1974.

The construction organization plan to be included in the SPR was the subject of continuous discussions which began in 1972; final negotiations, including those on the network chart, took place in July 1974.

Performance Plans

Energoprojekt developed a full range of construction performance plans, and also performance plans for the equipping of the primary section of the power station, on the basis of agreed-upon supplier-purchaser relationships.

The construction performance plans were developed by Energoprojekt itself pursuant to a January 1974 agreement between its management and FMPE which mapped out an extraordinary approach to the provision of planning documentation for the turbine room and "racks" [? of electrical equipment]. The construction performance plan for the primary section was supplied for Energoprojekt by LOTEP, and the general designer added to them the final details needed by the Czechoslovak general contractor for construction work (GDs). The construction performance plans for the other facilities were developed by Energoprojekt in the usual way.

The equipment installation performance plans for the secondary section were worked out by the general contractor for equipment (DGt) and his final suppliers, while the performance plans for the equipping of the primary section were provided by the general designer. Staff members of Electroprojekt and the Czechoslovak process equipment suppliers took part in the development of the performance plans for the primary section throughout their development in the Soviet Union.

Since the Soviet planning documentation was based on Soviet technical standards, it was necessary to secure the necessary exceptions to the Czechoslovak state standards. This work was carried out for the investor by Energoprojekt and the general contractor for equipment.

Designer Oversight

The general designer performed designer oversight through the entire construction period through a standing group located on the site of the V-1 station, as well as exercising expanded designer oversight through a separate organization which Energoprojekt established for this purpose in Trnava in 1974. As part of continuous designer oversight, Soviet specialists from LOTEP conducted designer oversight for the general designer starting in 1975. The number of specialists was determined according to the scale of work at the site and reached its maximum in the last year of construction, when about 25 persons were engaged.

Technical Design

The V-1 nuclear power station is located in an area which was intended for continued construction of facilities of the A-1 type, for which the site was largely prepared in advance. This choice of site was of great importance, making it possible to start work quickly, since the necessary surveys were available, all of the site's connections to the external mains could be used, and a tested construction organization and investor collective which had built the A-1 nuclear power station were present on the site. In deciding on the layout it was necessary to work from the existing condition of the site, and accordingly it was not possible to meet optimal requirements. The determination of the layout for this location envisioned the construction of the V-1 station as the final project on the site, and no further construction of new power stations on the site was provided for at the time.

The conceptual design of the V-1 follows the fundamental principles of design of nuclear power stations with twin VVER-440 units.

The main power production unit, containing two reactor units, each with an installed power of 440 Mwe, is a functionally and physically closed entity in terms of the process of electrical energy production and the handling of fresh and spent fuel, nuclear and fire safety, handling of radioactive wastes, entry into, exit from and passage through controlled zones, and control room design. The design of the operations building and its sewage loop, the installations for auxiliary radioactive operations, the diesel generation station, the compressor and refrigeration station, the facilities for chemical treatment of water and for circulation cooling, the central pumpings station, the equipment for circulation and technical cooling of water, the cooling tower, and the central workshop, warehouses and the like, are all related to the design of the main power production unit.

Process Layout

The process layout is a two-circuit design. The primary circuit produces heat energy and transports it to the steam generators. The chain reaction in the nuclear fuel (slightly enriched uranium oxide) liberates heat energy in the reactor core (heterogeneous, using thermal neutrons). This energy is carried away from the reactor by the coolant (chemically treated water), which is at a pressure of 12.25 MPa and a temperature of 269° C at entry into the reactor, and which also serves as a moderator. The thermal energy is removed from the reactor by six circulation loops consisting of Js500 circulation piping with gate valves at the entrances and exits to the raactor, the main circulating pump and the steam generator.

The secondary circuit produces electrical energy, using steam generated from the coolant circulating in the steam generators. Saturated steam from the steam generators is fed at a temperature of 258° C and a pressure of 4.6 MPa to the steam turbines (2 x 220 MWe per unit), which are provided with a moisture separator and steam reheater at the 0.49 MPa pressure divider (before entry to the low-pressure parts of the turbine). The turbine condensers are transverse two-pressure models and are cooled by circulation through natural-draft cooling towers. The condensate is returned to the coolant reservoir by a three-stage low-pressure regeneration system and a deaerator. The feedwater station feeds the steam generators through a two-stage high-pressure regeneration system.

The design of both circuits assures tightness so that the working medium in the secondary circuit remains nonradioactive.

Electrical Design

The basic circuitry of the V-1 power station is entirely modular. The electrical output of two 220-MW alternators in each reactor unit is fed from the unit's transformers via a common 220-kV cable to the higher-level substation at Krizovany.

The main alternators are of ordinary design with combined water-hydrogen cooling, but with special requirements regarding voltage regulation during combined steam and electromechanical runout. To assure greater reliability of the power supply to the main circulating pumps during various electrical disruptions in the station and the grid, generator circuit breakers were eliminated from the design of the basic electrical system.

The circuit for in-station power supply was designed to meet heightened requirements for reliability of the power supplies for in-plant propulsion in nuclear power stations; these power supplies are divided into three groups in terms of their importance for safety of the unit.

The first group consists of equipment which can suffer only brief interruptions of power (about 1 second). This includes in particular the primary circuit main circulating pumps, the reactor control and protective system, the instruments used to measure reactor parameters, the drive motors for the turbogenerator oil pumps and the like.

To assure sufficient heat removal from the reactor core, the main circulating pumps must assure the necessary coolant circulation in the primary circuit, even in case of an emergency shutdown of the reactor, for at least 100 seconds until gravity circulation begins. Because of the low inertia of the main circulating pump which results from its glandless design, electric power to the pump must be assured for the time period mentioned even in case of a shutdown of the reactor accompanied by complete degradation of the power system.

In addition, in order to assure reliable and stable operation of the unit, the simultaneous breakdown of more than two of the main circulating pumps must be ruled out in any breakdown of the station or the power system.

The second group consists of loads allowing power interruptions for a maximum of 3 minutes.

The third group consists of loads without particular requirements for power supply reliability.

In accordance with this categorization, the sources and power supply systems for in-plant power consumption are chosen as follows.

The working sources for in-plant power consumption are 25-MVA triple-wound regulating transformers fed from the output of the main alternators.

In view of the specific requirements for power supply to the main circulating pumps, 6-MW auxiliary alternators for in-plant consumption are mounted on the shaft of each 220-MW alternator as additional working power sources.

The reserve power supply for in-house consumption, which also provides the energy required for warming up the power station, consists of 110-kV and 220-kV systems with two 40-MVA three-phase triple-wound regulating transformers.

In case of an emergency cooldown of the reactor, the plant's emergency power supply uses the kinetic energy of the turbine system as it runs down and in addition uses six diesel generators with a capacity of 1,600 kW each. Small AC and DC loads in group 1 are fed by bidirectional motor generators or storage batteries.

The added care occasioned by nuclear safety concerns also extends to the cable runs; particular care has been taken to design them so as to minimize the consequences of fire.

The construction of the cable ways and the selection of cable routes assures that the equipment and systems which are most critical for operation will remain operational even if a fire occurs in the cable ways. A fire protection system for the cable runs allows extremely rapid extinguishing of fires.

Structural Design Principles

The installations of the V-1 power station which contain the process equipment and the systems of the primary section are of special design. These installations differ fundamentally in layout and design from those in power construction projects built previously.

The structures housing the primary section must be considered an inseparable component of the production equipment, subordinated to the aims of the power production process, which must proceed in accordance with nuclear safety requirements. The layout and design of these installations is principally governed by the requirement to protect the station's operators and surroundings from the harmful effects of its operation. This requirement resulted in the division of these installations into a number of independent compartments or "boxes," which are separated from one another by structural elements, walls and ceilings. The mass of the structural members gives protection from radiation effects, and they are provided with surfacing which assures that they are watertight and resistant to decontamination solutions and that the areas which they enclose are tightly sealed.

These components are made of special monolithic reinforced concrete and their surfaces are covered with sheet steel (painted carbon steel or stainless steel) or with special paint systems.

The accesses to these compartments (boxes) consist of cast iron doors for the operating personnel and built-in ports for piping and cables. This equipment may not deviate from the technical specifications applicable to compartments of this type.

Nuclear Safety and Radiation Protection Principles

The design for the V-1 power plant was developed in accordance with the health regulations for the planning of nuclear power plants. The equipment which could be a source of radioactive contamination is designed in accordance with the relevant standards regarding its design, production and quality control. Extraordinary emergency conditions arising from the worst possible failure situations must not subject employees or the public to radiation doses exceeding the permissible emergency levels.

The safety of the V-1's power plant systems is based on the assumption that there can be no failure of the Js500 piping, and accordingly the plans assume that the entire piping loop will be subjected to extremely strict quality control, regarding both materials and work, during its production and installation. All other smaller-diameter piping in this loop is connected to the main piping by means of nozzles which limit the outflow of coolant from the primary circuit, with an equivalent diameter of Js100. In these emergency situations the reactor is cooled by a boric acid solution which is added to the system by low-pressure pumps from an 800-cubic-meter tank. The primary circuit compartments are cooled in such cases by a spray system which is also supplied from this tank. The equipment and systems used to produce energy from the nuclear fuel are located in separate compartments ("boxes"), which are sealed off and are inaccessible to operating personnel during operation. During normal operation, a slight underpressure (15 to 20 mm of water) relative to the other areas is maintained in these compartments to assure that any radioactive leaks will not enter personnel areas or areas to which operating personnel have access during operation.

Radioactive leaks are exhausted from the sealed compartments by independent ventilating systems, pass through aerosol and iodine filters and are discharged into the ventilation stack. In case of an emergency associated with some other piping failure, the temperature and pressure in the sealed compartments will begin to rise. If the pressure reaches 30 mm H_2O, fast-acting valves close off the ventilation system and the compartments are completely sealed off from the surroundings. If the pressure rises to 0.11 MPa, the sprinkler system is automatically turned on. The sealed compartments are protected against unacceptable rises in pressure by large-diameter valves which release an air-steam mixture into the atmosphere.

The main technical characteristics and parameters of the JE V-1 power station (according to the planning design) are as follows:

1. Reactor--heterogeneous, moderated and cooled by treated water, enriched uranium fuel (VVER 440 type 230)

Number of reactors in power station	2
Thermal output of reactor	1,375 MWt
Installed electrical capacity of unit	440 MW (2 x 220 MWe)
Uranium charge in reactor	42 tons
Cladding material	zirconium alloy
Number of fuel assemblies in core	349
Number of control assemblies	37
Average uranium enrichment in stationary mode of operation	3.5 percent U-235
Expected burnup	28,500 MW-days per ton
Coolant temperature at reactor inlet and outlet	269°/300° C
Coolant circulation through reactor	39,000 m^3/hr
Coolant pressure	12.25 MPa (at reactor inlet)

2. Circulating pump--verticla, glandless, centrifugal

Number of pumps per unit	6
Capacity	6,500 m^3/hr

3. Steam generators--single-body, horizontal, cylindrical

Number of steam generators per unit	6
Steam generator output	124.7 kg/sec (450 tons/hr)
Steam temperature	258.9° C
Steam pressure	4.60 MPa (49 kg/cm^2)

4. Turbogenerators--220 MW steam condensation turbines using saturated steam at 44 kg/cm^2 and 256° C, triple-bodied

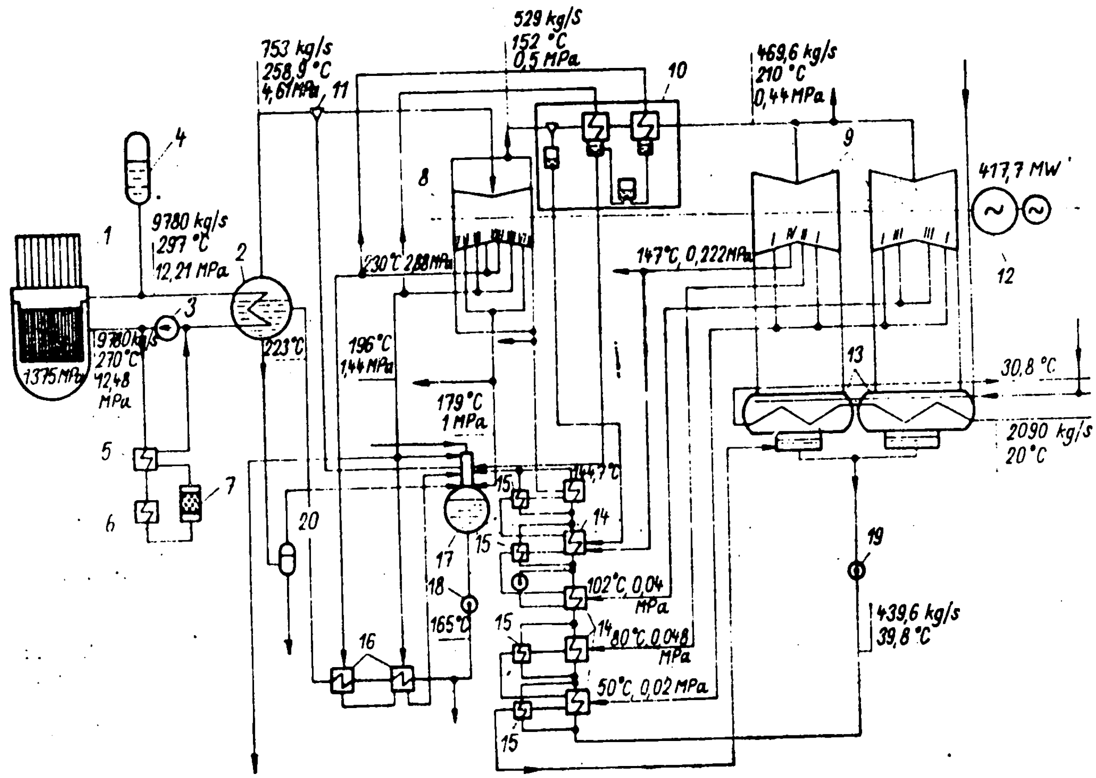
Number of turbogenerators per unit	2
Installed electrical capacity	220 MW

Power factor 0.85	0.85
Nominal voltage	15.75 kV
Alternator for in-plant power supply	6 MW; 6.3 kV (on common shaft)
Electrical capacity of power station at generator terminals	835.4 MW (2 x 209.0; 2 x 208.7)
In-plant power consumption at rated power station output	64 MW (07.66 percent)
Net efficiency of power station at rated output	28.05 percent
Annual production of electricity at turbogenerator terminals (gross assuming 6,500 hours/year use of thermal output of the reactor	5.430 TWh/year
Annual consumption of additional nuclear fuel	28.2 tons uranium per year
Production cost per unit of delivered electrical energy over entire year	Kcs 158.2 per MWh
Total number of employees	864
Heat given off to surroundings at rated capacity	1,978.6 MW
Quantity of heat given off to surroundings per year	46,372 TJ/year
Built-up area of enclosed site	48 ha

The construction of the V-1 power station was extremely demanding and involved a number of difficulties. These resulted primarily from the large scale and complexity of the undertaking, but were complicated, both during development of the planning documentation and during the construction itself, by the stepped-up nuclear safety requirements. A negative role was also played by other circumstances, particularly by uncertainty in purchaser-supplier relationships between the participants in the construction work.

These circumstances affected the quality and coordination of the planning documentation, its completeness and the times at which it was provided, and consequently resulted in a large number of additions to the construction and equipment parts of the planning documentation which were issued throughout the period of construction. The difficulties occasioned by this situation had to be solved by increased flexibility and by the use of a number of extraordinary measures.

Fig. 1. Diagram of unit



Key:

1. Reactor
2. Steam generator
3. Main circulating pump
4. Primary circuit steam compensator
5. Regenerative heat exchanger
6. Final cooler
7. Filter
8. Steam turbine high pressure section
9. Steam turbine low pressure section
10. Moisture separator and steam heater
11. Moisture separator
12. Main generator
13. Condenser
14. Low pressure regenerative heater
15. Condensate coolers for low temperature regenerative heaters
16. VTO (high pressure heaters)
17. Makeup water supply with deaerator
18. Feedwater pump
19. Condensate pump
20. Steam generator drainage expander

To insure the performance of this work and to solve problems arising on the project as a result of running revisions of construction and installation work plans, a group of designers was set up at the construction site, led by the general designer's chief design engineer.

Represented on the group were all the main participants who were working out the planning documentation: Energoprojekt, Skoda, Elektromontazny zavody [Electrical Installation Plants], Zavody prumyslove automatizace [Industrial Automation Plants], Sigma, Kralovopolska strojirna [Kralove Pole Machine Works], Termostav, Potrubi, Janka, Hydrostav and others. The composition varied with the needs of the project. The investor and operator organizations took part in the work of the group, and its activities were monitored by the Management and Startup Group, the Operations Staff, and ultimately by the Interdepartmental Startup Committee.

Particularly stringent demands were imposed on coordination between the Soviet and Czechoslovak planners, and for this purpose the Soviet side provided about 100 consultations.

In conclusion we may state that the V-1 nuclear power station was successfully started up in 1978-1980 and that its subsequent operation has given the best possible results, owing particularly to cooperation with the Soviet specialists during construction and into the first stage of its operation.

Staff members of the general designer organization and all other participants in the construction project gained priceless experience during this cooperation in the building of the V-1 power station, which will be used in the construction of subsequent power stations of the same type.

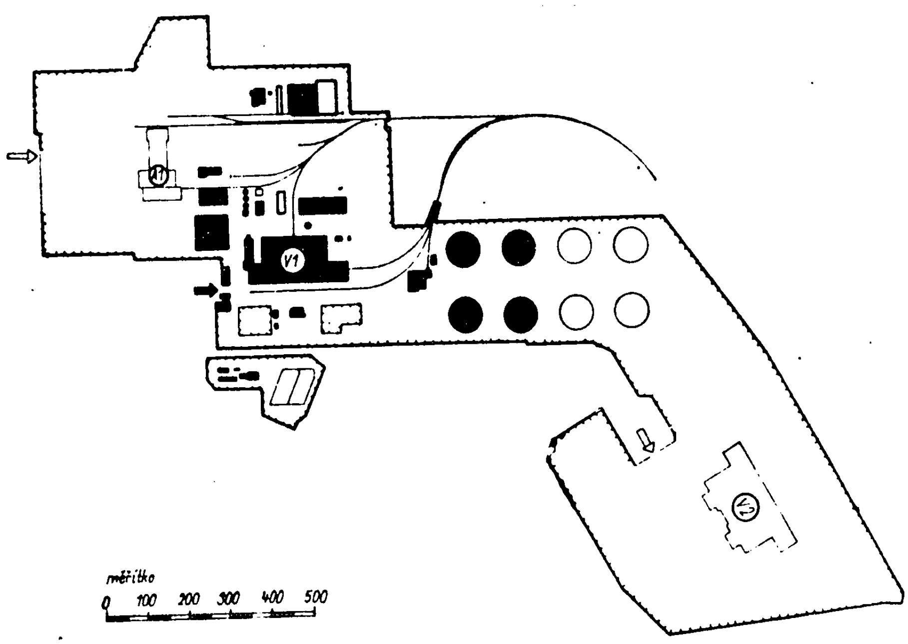


Fig. 2. Layout of Site at Jaslovske Bohunice

8480
CSO: 5100/3019

CONSTRUCTION WORK ON V-1 POWER STATION DESCRIBED

Prague JADERNA ENERGIE in Slovak No 4, Apr 81 pp 126-129

[Article by Jan Lasko, Hydrostav National Enterprise, Bratislava: "Performance of the Construction Work for the V-1 Power Station"]

[Text] The orientation of the Czechoslovak power industry toward nuclear power stations, which under our conditions are the only promising source of electrical energy, means a major change in the production program for the construction industry.

The construction of nuclear power stations represents a major divergence from traditional industrial construction, especially in the installations whose operation involves radioactivity, where the nature of certain materials and construction members is more reminiscent of the machine-building sector as regards both requirements for precision fabrication and problems of installation.

These important changeovers to materials and structural members (and the requirements to which they are subject) which are unfamiliar in the construction industry, involve certain complexities and give rise to a number of problems in mastering production processes. The main units of unconventional design are modules made of steel, preassembled beam packages, metal facings for walls, ceilings and floors, passages through walls, and various built-in components which must be installed with high precision. They also include large quantities and a wide variety of metal materials, carbon steel and austenitic steel sheet, and special heavy concretes and fillers.

Large numbers of passages and anchoring components built into the walls are subject to installation precision requirements which sometimes surpass the production tolerances of the metals from which they are made, so that they must be machined.

The investment and planning preparation had a major effect on the process of constructing the V-1 power plant. The participation of two design organizations, LOTEP in Leningrad and Energoprojekt in Prague, using different forms and different practices regarding the level of detail in technical development of the planning documentation, and using different standards and regulations, not only led to revision of the planning documentation for Czechoslovak practice, but also slowed down delivery of performance plans.

Performance of the construction work was also negatively affected by the breaking down of performance plans for facilities in the main power production unit and the underground piping system into an excessive number of steps, and by additions, changes and conflicts in the planning documentation. These circumstances caused the construction contractor additional toil in both production preparation and the work itself, and during construction it led to increased labor and financial expenditures for the provision of capacities which in any case were insufficient.

The investment and planning preparation involved a large number of exceptions from regulations and notices, which on the one hand enabled the investor to speed up preparation, but on the other caused the supplier organizations special difficulties stemming from extremely short lead times in the production preparation stage. These circumstances forced the construction contractor to engage in improvisations and had a negative effect on organizational economics. Based on specific economic results, the construction of the V-1 power plant with top social priority proves to have been disadvantageous to the enterprise.

Construction of the V-1 power station began with the excavation of the main power production unit on 25 April 1973 in a location where basic capacities were already available and which already had certain basic facilities in place from during previous construction work. Construction began simultaneously on the other capital installations and on the construction site facilities.

By the end of 1980, the Kcs 974.1 million which had been budgeted for construction work on the V-1 power station had increased by 57.6 percent to Kcs 1,535.1 million.

This increase in budgeted expenditures was caused primarily by requests for additional work and deliveries for both the permanent facilities and the construction site facilities.

About 140 capital installations and about 400 construction site facilities and MGZS [expansion unknown] were built on the construction site of the V-1 power station. In view of the unique nature of the construction, the extraordinary scope and demandingness of the design and the unusual precision required in construction, the construction site facilities were built by the independent accounting method.

Because of the scope, technical demands and the necessity for carrying out associated construction and installation work concurrently, the construction of nuclear power stations requires a high concentration of construction capacities and also demands a new approach and attitude on the part of all supplier organizations taking part in the construction work.

Owing primarily to a shortage of capacities, construction work was carried out on a single-shift basis, using extended shifts during favorable conditions in the summer months. At certain times, when the equipping of the station demanded it, or when it was necessary to meet certain construction completion deadlines, work went on continuously, and even on days off when necessary. The maximum complement of 2,675 workers was attained in June, 1977. This figure included employees of HDS [expansion unknown] subcontractors, foreign workers, and employees of Hydrostav National Enterprise who were providing services involving primarily provisioning, housing, and maintenance of construction site facilities. The number of workers performing these services was far from insignificant amounting to about 250 persons.

Between June 1975 and December 1978, about 114 workers from Yugoslavia worked on the site, a while about 71 workers from Poland worked on the site from June 1977 to December 1978.

Table 1 shows the average numbers of workers called for the construction organization plan [POV] and the actual average complements:

	1972	1973	1974	1975	1976	1977	1978	1979	1980
Number of workers according to POV	210	1000	1600	2200	2400	2000	2150	450	170
Actual number	140	650	1360	1770	1915	2411	1598	619	212

In 1976 and 1977, the most complex years of the construction project, when deadlines for construction completion had not been met, the construction contractor came under pressure to constantly increase his work capacities. Hydrostav National Enterpirse increased its construction capacities by 660 workers between the beginning of 1977 and June 1977, thus creating the conditions for movement toward plan fulfillment. The shortage of construction workers manifested itself primarily in the specialized trades (carpenters, ironworkers, welders).

If we compare the V-1 construction manpower with that used on similar projects in other countries (Nord Lubnin in East Germany and Kozloduj in Bulgaria, among others), we find that the average construction manpower employed from the beginning of construction to the end of the phasing-in of Unit 1 into the power system was relatively small.

The state plan called for construction work worth Kcs 575 million to be done on the V-1 station during the Fifth Five-Year Plan. The actual amount of construction work done during this period was slightly more than Kcs 600 million, with the result that the construction work volume assignments for the short-term plans were overfulfilled every year during the Fifth Five-Year Plan. Hydrostav National Enterprise also successfully fulfilled the state plan during the Sixth Five-Year Plan, when the planned volume of construction work, Kcs 684.4 million, was exceeded or matched by a total construction work volume of Kcs 934.9 million. This means that from the beginning of construction to the end of 1980, construction work worth 1,535.1 million korunas was done on the V-1 station.

	1972	1973	1974	1975	1976	1977	1978	1979	1980
State plan (million Kcs)	22.0	79.3	193.8	262.2	282.2	210.3	116.3	41.0	35.9
Actual volume (million Kcs)	26.4	106.9	197.9	266.0	327.2	305.3	178.0	80.9	43.5

As can be seen from this survey of finance figures, Hydrostav National Enterprise had favorable annual fulfillment figures for construction work throughout the construction period, thanks to the use of many forms of worker initiative and to systematic introduction of advanced construction procedures aimed at decreasing labor inputs and replacing trades that were in short supply. There were shortfalls in fulfillment of the material figures for construction readiness in the critical years of 1976 and 1977 on individual facilities according to the network chart, and an average of 24 construction readiness deadlines went unmet each month. By the second half of 1977, following a substantial increase in construction capacities, there was a turn for the better and shortfalls in construction completion were made up.

From the beginning of construction of the V-1 to the end of 1980 the following material performance figures were posted:

Excavation	1,537,000 m^3
Simple concrete	121,924 m^3
Reinforced concrete	203,950 m^3
Heavy concrete	2,230 m^3
Cement surfacing	313,965 m^3
Paneling	460,093 m^3
Reinforcement	121,611 quintals
Bricklaying	27,190 m^3
Masonry walls	64,063 m^2
Cast iron facings	23,326 m^2
Austenitic steel facings	13,840 m^2
Exterior facing, Bolet. panels	5,708 m^2
Syporex panels	7,395 m^2
Special Beloplast flooring	17,600 m^2
Special Fortit flooring	2,700 m^2
Steel structural members delivered	8,772 tons

The performance of this demanding construction work from the beginning of excavation for the main power production unit to the phasing into the power system of Unit 1 on 17 December 1978 lasted 5 years, 8 months.

The performance of the construction work required the use of new, progressive procedures and efficiency-improvement measures. Practically all branch plants of Hydrostav National Enterprise took part in construction. We should take the opportunity to give a high evaluation to the participation and good cooperation of Hydrostav's subcontractors in this important project (for example, Armabeton Praha (Cooling Tower Plant and Plant No 10), Hutny Montaze [Metal Installation] Ostrava, Termostav Bratislava, Janka Radotin National Enterprise, Transporta Praha, Stavoindustria Bratislava, Geoindustria Brno and so on).

A wide range of workers from Hydrostav National Enterprise and staff members of its own research and development base took part in designing many complex construction procedures. During preparations and during construction itself, Hydrostav made effective use of the assistance and cooperation of scientific and specialized institutions in Czechoslovakia, such as the Welding Research Institute in Bratislava, the Slovak Academy of Sciences, the Slovak Advanced Technical School, the Research Institute of Construction Engineering and so on.

Many advanced procedures were used during the preparation and construction of the V-1 power station.

For example, an unconventional method was used to install the facilities for the main power production unit and to protect the excavation pit for the boron facilities of Units 1 and 2.

Packing of the foundation soil below the reactor room, consisting of light loess alternating with clay strata, which in addition to their compressibility have an undesirable tendency to shift, particularly when wet, was carried out by tamping, i.e. by pounding the soil with a 7 ton weight falling from a height of 8 meters. Under the base plate of the reactor room, a so-called consolidation zone of B-60 concrete 2 meters thick was installed. The turbine room was set on enclosing foundation ditches and the wall of Turbine Room B next to the reactor installation was laid on Franki system piles. In locations where compression of the foundation soil could sometimes be done in the winter, if there was a danger of freezing or waterlogging of the foundation, the foundation layer was reinforced by using cast-in-place sand-and-gravel piles.

Some 67 to 70 percent of all paneling work was done with IS-NOE system paneling (Universal, Combi 20, Combi 70), produced under license at the Hydrostav branch in Trencianske Bohuslavice. The high maneuverability of this paneling system gave a saving of 20 percent on production expenditures compared with traditional paneling, and a saving of 35 percent on labor inputs. When paneling the turbogenerator roof beams and heavy ceilings, Hunnebeck system support members were used successfully.

As part of its own research, Hydrostav national enterprise developed a process for producing heavy concrete using domestically available ingredients. The production of heavy concrete met the requirements of Czechoslovak State Standard 732400 for Class 4 concrete with a density of 3650 kg [per cubic meter].

The production of concrete mixtures was carried out in the remodeled BT 440 concrete plant which HDS had previously used in the construction of the A-1 power plant. In this concrete plant are installed two Vinget type mixers, each with a capacity of 1,500 liters. By using this arrangement Hydrostav saved considerable foreign exchange. The heavy concretes were produced in a separate ELBA 25 concrete production unit. A sand-gravel quarry was built on the right bank of the Vah River at Leopoldov, about 18 km from the construction site. A Swedala-Arbra classifier was built in this location.

Horizontal transport of the concrete was generally carried out by cement mixer trucks, and vertical transport by concrete pumps. Horizontal transport of heavy concrete from the production unit used horizontal "tub" containers installed on trucks, and vertical transport was done with tower cranes.

A high level of mechanization of cutting and fitting work in the stamping shop, using Pedinghaus equipment with a capacity of 7,000 tons a year, made possible increased efficiency through prefabrication of ceiling and wall members.

The workers of Hydrostav National Enterpirse managed in a relatively short time to master the complex process of welding and installing large-area wall, floor and ceiling facings using both carbon steel and austenitic steel.

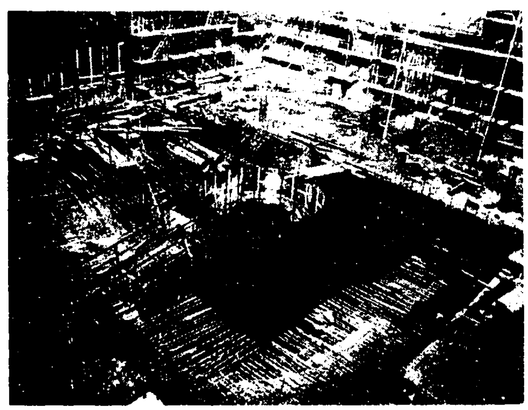


Fig. 1. Construction of the reactor room.

Among other successful solutions we should mention the advanced system for facing the HVB [main power production unit] facilities and the other auxiliary facilities of the V-1 power plant by means of connected large-area foamed concrete panels. We should also note here the beneficial use of advanced Promonta preassembled partition walls with a nonplastered surface which, when there were many partition walls to be built, saved labor and scarce capacities. The workers of Hydrostav National Enterprise, together with the Slovak Academy of Sciences and the Research Institute of Construction Engineering, managed to develop a surface protection for concrete in the strict regime areas of the power station using epoxy systems. The paint systems used, consisting of epoxy varnishes and enamels, were domestically produced.

The findings and experience obtained in the process of constructing the Unit 1 of the V-1 power station have manifested themselves in a considerably greater smoothness of construction work on the Unit 2, and have extensive application in the current construction of the V-2 power station. In this project, with three times the area of carbon steel and austenitic facings as in the V-1, semiautomated production of the large-dimension facing panels has been introduced and has led to time savings and a reduced requirement for scarce trades, with a consistently higher quality. Only the installation welds on site, or in spaces where the established procedure makes it impossible to industrially prefabricate large-size facing panels, are done manually.

In the construction of the V-2 power station, the concept of using prefabrication in the sealed and nonsealed zones is used to the maximum extent. In the V-1 power station, only a ceiling at a height of +10.5 meters was prefabricated in the reactor room facility. In this connection it was necessary to use tower cranes of considerably greater capacity.

In developing the design for the roof facing a changeover was made from wet application processes to the installation of insulating panels on a support base, using asbestos cement BDP panels with a Vistomat liner on a support base fastener to steel U shapes, which was the most proven approach.

This briefly described trend toward the use of efficiency-improving measures and the intorduction of progressive procedures is being implemented at the V-2 power station and will be developed more extensively and successfully in the implementation of this important program in the future.

The extensive collective of the Hydrostav National Enterprise has won a high social evaluation for the results of its work in the construction of the V-1 power station.

We may state on behalf of Hydrostav's employees that they will be ready in the future to do everything possible to carry out the demanding program for developing nuclear power production in Czechoslovakia.

8480
CSO: 5100/3019

INSTALLATION OF EQUIPMENT AT V-1 POWER PLANT DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 pp 129-133

[Article by Jiri Prochazka, Stanislav Stepanek and Josef Drahy, Skoda Regional Enterprise, Plzen: "Experience in Construction and Installation of the V-1 Power Station"]

[Text] This article gives information on the construction approach with reference to the delivery and installation of equipment. The installation of the primary circuit and test assembly of the reactor components is analyzed. The article also describes the 220-MW saturated-steam turbine, which was put into operation for the first time at the V-1 power station.

With the construction of the V-1 nuclear power station in Jaslovske Bohunics, Czechoslovakia entered the era of commercial production of nuclear power, and it must be stressed that this conspicuous success was attainable only with the extensive help of Soviet specialists. This help involved a number of sectors. From the point of view of the general contractor for the equipping of the V-1 station, we should cite particularly the areas of deliveries, installation coordination, and special installation. In the construction of the V-1 power station (i.e. a power station with two reactors, each with a capacity of 440 MW, of type V-230), Skoda Regional Enterprise functioned as the senior equipment contractor on the full scale only for the secondary section, while for the primary section it chiefly provided Soviet deliveries and Soviet installation coordination and special installation services, in addition to performing installation of the primary section according to Soviet performance plans. The startup of the entire power station was organized by the investor through the operators of Bohunice Power Stations [EBO] and Soviet startup specialists. This complex and demanding construction approach was chosen because when planning work was begun in 1970 Czechoslovak industry was not yet ready to produce the main control components of the primary section. Soviet deliveries amounted to about 50 percent of the power production equipment. In developing this construction approach, it was also necessary to take account of the fact that there is a difference in conception between the Soviet and Czechoslovak systems for preparing and carrying out the construction of nuclear power stations, which can be summarized as follows.

In the Soviet Union, not only the necessary planning-engineering and construction-installation capacities, but also the production of a number of types of operating equipment, are included in the power ministry. Accordingly there is day-to-day contact between these elements. The Soviet system does not employ the senior contractor function, and the equipment aspect of a power station is broken down into functional systems and circuits without regard to the future composition of the supplier mechanism. The second stage of planning (performance planning for functional systems and circuits), including the coordination arrangements, is worked out by the planning organization which develops the first stage plans, using data from manufacturers involved with orders for individual peices of equipment and piping systems, supported by specifications from the performance plan. All coordination and set assembly activities during preparation for and performance of construction are carried out by organizations in the purchasing ministry, including preparation for and performance of startup.

Czechoslovakia uses a system in which the general contractors for equipment and for construction and the general designer are partners of the investor organization. In this case the planning documentation for the power station is divided up into construction and equipment sections. The equipment section is broken down into operating sets and partial operating sets in accordance with the way in which they are to be supplied by the contractors. The operating set and partial operating set are the province of the senior final supplier. The preliminary plan, which as regards detail and structure is the first stage of the plan worked out by the general designer, is intended to be a complete basis for the working-out of performance plans by the final suppliers. Accordingly a way must be found to include in it directions regarding procedural, planning and engineering matters and the closely associated details of contractor and supplier performance. The equipment performance plans developed in the Soviet Union were revised for Czechoslovak practice, including division into operating sets and partial operating sets; problems arising on site, including those of heightened nuclear safety requirements, were solved by consistent coordination of supply and by changes and additions to the equipment performance plan.

Work involving differences between Czechoslovak and Soviet standards was also extermely demanding; this made itself felt not only in the plans, but particularly in deliveries of electrical equipment and monitoring and control systems produced in the Soviet Union. In the technical preparation for installation, the complexity of the conditions resulted from the fact that the production documentation arrived from the plant with the last shipment, and accordingly it was not possible to organize installation procedures and the associated production of fixtures, provide the tools and the like, sufficiently in advance. However, at the construction site there was complete cooperation between the Czechoslovak and Soviet workers, foremen and engineers, who were organized into international brigades and through whose initiative the tasks were accomplished. Their commitments made it possible to overcome even the most complex problems, and to meet deadlines comparable to international standards in installation work. For example, in Unit 2 of the V-1 station the welding of the Js500 piping of the main circulating loop, once it was in place, was accomplished in 30 days, and the installation of the six main circulating pumps on the Js500 piping took only 20 days. However, the main finding remains that only well-prepared installation work based on a knowledge of the blueprints, their development into installation procedures, and the provision of all necessary fixtures, including timely deliveries, will create the optimal conditions for carrying out the construction work. Another entirely indispensable factor is continuing contact with the producing plant and its workers and engineers, which not only makes possible resolution of the most complex situations as they arise, but also creates feedback between the installation site and the equipment production facility. In addition, coordinated installation is essential in the construction of nuclear power stations, and it requires close contact between the designer, the project engineer and the builder, both in working out a coordinated procedure and in resolving possible conflicts. Accordingly it is impossible to dispense with any of the technical specifications which require that installation proper be performed in coordination with the producing plants, when degree the surface and interior cleanliness of the nuclear equipment is specified.

The installation of the primary circuit, consisting of the main control components of the primary section, i.e. the reactor system, six steam generators, the volume compensator, six main circulating pumps, 500 mm stainless steel piping, the main gate valves and the like, was made particularly difficult by the fact that it involved unconventional, outsize, extremely heavy equipment with exacting technical specifications, and by the fact that it was impossible to acquaint oneself with the production documentation and technical specifications sufficiently in advance. It should also be realized that the installation of these components had to be almost error-free as regards function and quality, because this equipment must operate for its entire lifetime without major defects. Under the prescribed procedures, most repairs are extremely difficult, since they involve work in a radioactive environment. The technical demands made by this installation work are best seen from the following characteristics:

Pressure vessel	
height	11,800 mm
maximum diameter	4,270 mm
weight	201 tons
maximum wall thickness	205 mm
Upper unit [reactor control and protective mechanisms]	
height	11,700 mm
maximum diameter	3,836 mm
weight	114 tons
Reactor barrel [sachta]	
height	8,122 mm
maximum diameter	3,366 mm
wall thickness	60 mm
weight	37.6 tons

Base of reactor barrel	
height	4,185 mm
maximum diameter	3,005 mm
weight	30 tons
Core basket	
height	3,930 mm
maximum diameter	3,080 mm
weight	22 tons
Bank of guard tubes	
height	6,685 mm
maximum diameter	3,190 mm
weight	35.2 tons
Steam generators	
number per unit	6 steam generators
	24 suspensions
length of shell	11,570 mm
internal diameter of shell	3,210 mm
wall thickness	75-142 mm
weight	145 tons

On the basis of transport considerations, the reactor pressure vessel was delivered to the site with 10 connections attached, while the other two had to be welded on in the inspection manhole. The pressure vessel was installed in the concrete pit using a 250 ton crane at the minimum possible speed (microdisplacement). In setting the pressure vessel on the support ring, the following specifications had to be observed:

--coincidence of axes I-III and II-IV of the support ring with those of the pressure vessel;

--maximum permissible deviation of seating surface below the upper unit at 3,480 mm diameter equal to 0.5 mm.

After the pressure vessel was adjusted, the interior components of the reactor were test installed and the individual internal components were fitted to each other and to the pressure vessel. During installation, the following precision requirements were observed:

--main axes I-III and II-IV of the barrel, the barrel base and the upper unit had to correspond to the principal axes of the pressure vessel; the maximum permissible deviation of the axes was 1 mm at 4,270 mm diameter;

--the maximum deviation of the vertical axis of the ARK [emergency control assembly] drive housing in the upper unit relative to the tubes in the barrel base at a distance of 19.5 m was 4 mm;

--the maximum error of fit between the barrel base and the core basket measured at any point could not exceed 0.4 mm;

--when the barrel was installed in the pressure vessel, the seating surface of the barrel base had to be maintained within 0.5 mm of the horizontal plane at a diameter of 3,065 mm.

The most important operations in installation of the steam generators were: welding on the collectors and steam generator supports, creation of a prepressure in the Js500 primary loops by filling the steam generators, removing the protective coatings from the inner surfaces of the steam generators on the primary and secondary sides, and a pressure test of the steam generator shell on the secondary side. Particular attention was devoted to removing the protective coating from the steam generators, since they came from the production plant with a coating of oil which was extremely difficult to remove.

A consistent finding from the installation of this operating set is that it is possible to achieve very good coordination of production capabilities and the shipping of the main reactor system control assemblies from the plant with the needs of the construction project regarding maintenance of a continual installation process and coordination with the programs for startup and adjustment work. This involves use of the plant's technical capabiliites for test assembly and step-by-step shipment, i.e. first the reactor barrel, which is essential for circulation flushing of the primary loop, and then the other internal components and the upper unit. In this approach to installation there is no increase in risk resulting from the plant's not carrying out complete test assembly before all of the interior components and the upper unit are sent to the construction site. However, close ties between the plant's personnel and the installation personnel must be maintained.

The technical specifications specify precisely the operations which are carried out at the plant (any defects are instantly corrected by specialists) and the testing work which by its nature is suited to the installation site (discovery of problems occurring during transport and the like). To give a more detailed explanation, let us refer to experience regarding the step-by-step test assembly of the VVER-440 type 213 reactors produced by the Skoda Regional Enterprise. The pressure vessel of a nuclear reactor is the main barrier which contains the high-temperature, high-pressure primary coolant and prevents the escape of radioactive substances. The interior parts of the reactor serve to contain the core, to limit coolant flow paths and to guide the control rods and the leads of the measuring devices inside the reactor. Correct positioning of the individual components inside the reactor relative to each other and to the pressure vessel, and particularly relative to the upper unit, is extremely important for safe reactor operation as regards both reliable core cooling and reliable operation of the control rods, which are the only movable parts in the reactor and which pass through the entire reactor and all its interior parts with relatively small clearances.

Because of the large dimensions involved, the production of nuclear equipment is a relatively precise activity, but nonetheless individual tolerances may not be compatible with each other. This may lead to difficulties in installation or poor control rod movement through the channels during operation. Accordingly, test assembly is required in the production of nuclear reactors; in it, the correctness and precision of fabrication of the individual reactor components are checked, their installation compatibility tested, their optimal mutual adjustments selected and noted, and possible alteration and fitting of parts carried out in order to assure smooth installation and demounting of the reactor at the nuclear power station.

Ideally there should be a complete test assembly of the entire reactor at the producing plant. In this case, test assembly would cover the following main reactor assemblies:

a. pressure vessel
b. upper unit
c. barrel
d. barrel base
e. core basket
f. guard tube bank
g. inserted rod
h. control rod drive
i. electrical equipment and measuring devices
j. servicing platforms and equipment

It is obvious that for many reasons, primarily involving time and economics, it is simply infeasible to carry out full-scale test assembly. In production this would mean holding large-size completed components at the plant, with all the attendant consequences, and with the imposition of a considerable strain on transport facilities when all components were shipped together; for the power station, this would be entirely unacceptable in terms of the progress of construction work. It is particularly unrealistic to hold back the pressure vessel for test assembly, since it must be at the construction site early. The pressure vessel, which is a component of relatively simple shape, or its inner surface, which alone is involved in test assembly, can be replaced without difficulty by a mockup on which the main actual measurements of the finished pressure vessel are shown precisely. This basic test assembly approach includes all of the components mentioned above except the pressure vessel. Further analysis of the design, operating function, and purposes of the individual components in the test assembly with reference to the production and time demands applying to some components such as the upper unit, and with consideration for optimal progress of work at the construction site and for the transport and storage facilities, indicates that a simpler test assembly approach is more suitable. The simplification is based on two main circumstances:

--the reactor barrel is not involved in guidance of the control rods, and accordingly during test assembly it is necessary only to measure its relationship to the pressure vessel (or the mockup) and its installation compatibility with the barrel base; in the other test assembly operations it is possible to replace it entirely with a substitute barrel, e.g. the barrel of another reactor that is in production;

--in testing the coincidence of the axes of the remaining components (the upper unit, the barrel base, the core basket and the guard tube unit), the upper unit may be replaced by a complete cover, while the positions of the remaining parts of the upper unit can be shown individually.

There exist other less fundamental variations, such as transferring the test assembly of the electrical cables to the construction site and associating it with final installation, and the like. The approach to test assembly which has been described can be considered fully equivalent to complete test assembly of the reactor using all of its components. It gives the producer and the operator sufficient information to assure smooth installation on site and is also favorable as regards the progress of work on the station, since it makes it possible to supply the pressure vessel well in advance (as much as a year) and to deliver the barrel almost 3 months in advance of the other components.

In the secondary section, among the most importants are those of the 220 MW turbosets. In particular, the turbine itself, which uses saturated steam, is a new design, the conception for which took account of the following circumstances:

a. The pressure of the input steam of a saturated-steam turbine is comparable to the pressure of the heated steam before the medium-pressure sections of steam turbines in conventional power stations, while the input temperature of saturated-steam turbines is considerably lower.

b. The isoentropic enthalpy drop of saturated-steam turbines is half that of large turbines in conventional power stations, which for comparable power output means that turbines in nuclear power stations have approximately twice the mass of input steam.

c. The steam parameters before entry into the low-pressure section of saturated-steam turbines and turbines in conventional power stations are equivalent.

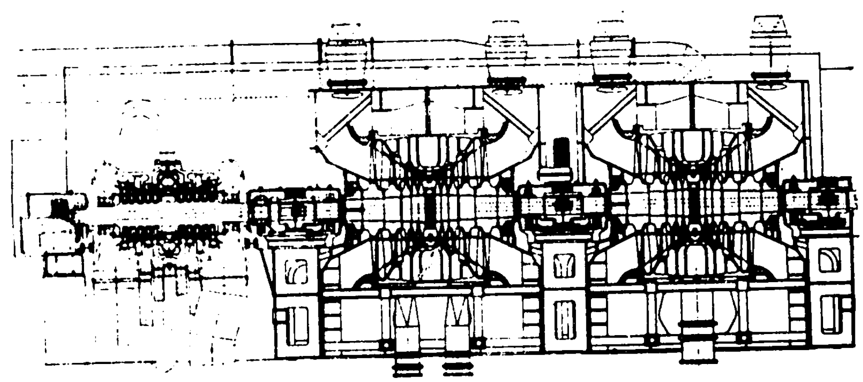
Since the decision had been made in 1972 to use a "full" speed of 3,000 rpm (rather than the "half" speed of 1,500 rpm as was the case in most saturated-steam turbines abroad) for saturated-steam turbines with capacities up to 1,000 MW, the conditions described above led to the following concept of the 220 MW saturated-steam turbines:

--the high-pressure section of the turbine would be derived from the medium-pressure section of a 500 MW turbine for conventional power stations and would have a double-flow design (in the entire comtemplated power range up to 1,000 MW); in view of the flow of high-pressure wet steam in the high-pressure part of the turbine, a material with high resistance to corrosion and erosion would have to be selected for the stator and rotor components;

--the two low-pressure sections of the 220 MW turbine would be completely derived from the two low-pressure sections of a 500 MW turbine for a conventional power station, and the blades of the final low-pressure stage would be used similarly in both types of turbines.

Not only the 220-MW steam turbines, but practically the entire secondary cycle of the nuclear power station with the VVER-440 reactor, was developed in Czechoslovakia, with the exception of the separator-superheaters, which are of Soviet design. The

200 MW steam turbine is designed for input saturated steam at a pressure of 4.32 MPa (temperature 256° C), with an absorption capacity of 377 kg/sec and a nominal cooling water temperature of 20° C. Fig. 1 shows a longitudinal section of the turbine, consisting of a high-pressure section and two double-flow low-pressure sections. The steam exits from the high-pressure section to the separator, where the moisture is separated from the steam down to a value of about 0.5 percent, after which it is fed into a two-stage heater, where bled steam and live steam are used to heat the steam to a state of 0.46 MPa and 216° C before it enters the low-pressure section of the turbine. The condensate is heated in 7 regenerative heating stages, including five low-pressure and two high-pressure heaters, to a final temperature of 222° C. The two condensers are connected in series in a "two-pressure" arrangement; with a coolant water temperature of 20° C, the pressure in the first condenser is 5.35 kPa and that in the second 6.84 kPa. The turbine is equipped with an electronic-hydraulic regulating system, and throttle-type turbine regulation is used. Modules consisting of one fast-closing and two regulating valves are symmetrically located on both sides of the high-pressure turbine section. Before each low-pressure turbine section is a pair of fast-closing valves to protect the machine against overrunning in case of an abrupt drop in load.



Obr. 1. Podélný řez turbínou

Fig. 1. Longitudinal section of the turbine

Typical design features are as follows:

--the double-flow high-pressure section, with six stages in each flow, is more suitable than the single-flow design in terms of symmetrical removal of steam from the high-pressure section to the moisture separator and of a unified conception of the entire series of saturated-steam turbines with capacities up to 1,000 MW;

--a bridge-type design is used for the two-layer housings of both low-pressure sections, with a combination of welded-together die stampings and steel castings for the inner shell and a completley-welded outer shell; the transverse "bridges" about 10 m long and 3.7 m high hold the turbines's radial bearings;

--the limited size compound low-pressure rotors all consist of a shaft and hot-pressed disk with four stages in each flow; the weight of a single low-pressure rotor is 45 tons. Fig. 2 is a photograph of a low-pressure rotor;

--the blades of the final low-pressure stage are 840 mm long and are fastened to the disk by direct rooting; these blades have been tested in operation in 24 turbines of 200 MW capacity in conventional power stations in Czechoslovakia and abroad; the blades are protected against excessive vibration by two rows of crossing damping wires, while protection from erosion by droplets in wet steam is provided by electric spark-applied hard metal on the leading edges and the upper parts of the back edges of the blades; to allow prolonged operation of the turboset either at idle or with small load, the output parts of the low-pressure sections are provided with cooling by sprayed-in condensate.

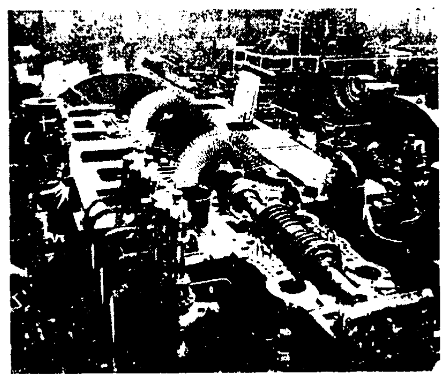


Fig. 2. Low-pressure rotor of the turbine

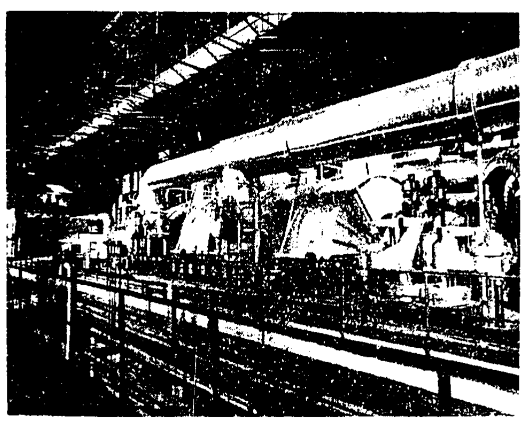
The Jaslovske Bohunice power station, whose turbine room is shown in Fig. 3, currently has four 220 MW turbosets in operation. The operating results have been positive; following the elimination of certain "infantile disorders" in the first phase of operation they have been working extremely reliably, and the assigned targets as regards both regulation during an abrupt drop from the nominal turboset power and moderate heat consumption, have been met.

One of the "infantile disorders" which showed up during trial operation and had to be set right involved the problem of a signal link between the primary and secondary circuits (involving both analog and digital signals) to increase reliability and operating safety. This involved, for example, a direct signal link between the reactor regulator and the turbine regulator aimed at preventing the operators from imposing an unsuitable regulation structure on the unit. Also involved was a signal link between the circuits for evaluating the operation of the main circulating pumps and the turbine regulator, which solves the problem of maintaining the pressure in the main steam collector when one or two of the main circulating pumps break down. There were no complications in installation.

Fig. 3. Turbine room of the V-1 power station

In conclusion, let us thank all 18 final suppliers for their high-quality products and their good work on the V-1 power plant in Jaslovske Bohunice. The production of more than 4.2 million MWh of electricity in 1980, representing a 37 percent overfulfillment of plan, is the best demonstration of its successful and relaible operation at the planned parameters, and thus is an evaluation of everyone's work on this power station.

8480
CSO: 5100/3019



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000400060013-7

WORK OF INVESTOR ORGANIZATION ON V-1 STATION DESCRIBED

Prague JADERNA ENERGIE in Slovak No 4, Apr 81 pp 133-137

[Article by Stanislav Smatlak, IVES [Slovak Investment Company for Power Construction] Bratislava, and Martin Svirko, IVES Jaslovske Bohunice: "Preparation For and Performance of Construction of the V-1 Nuclear Power Station"]

[Text] The construction of nuclear power stations in Czechoslovakia must be considered a new, special problem for the investment process, which in addition to the basic, characteristic traits associated with the construction of large capital projects also has a number of specific, distinctive features, such as concentration of a large investment volume in a relatively small geographical area, the close interconnection between the construction and equipment aspects of nuclear installations, involving the use of uncommon structural components and pieces of equipment and treating radiation safety as a functional element which affects design, manufacture and construction, and the entire startup process. The preparations and the entire process of constructing the V-1 power station in Jaslovske Bohunice, the first of a series of power stations in Czechoslovakia with VVER 440 reactors, were carried out in this context.

Preparation for the construction of the V-1 nuclear power station was based on the principles established by the Intergovernmental Agreement of April 1970 between Czechoslovakia and the Soviet Union, which laid down the basic principles for participation and reciprocal relations in the construction of two nuclear power stations in Czechoslovakia, each with two VVER 440 units. Among other things, the agreement stated that deliveries from the Soviet Union (of plans and equipment) would be made in accordance with Soviet standards and practices.

In May 1971 the foreign enterprises Tekhnopromeksport in Moscow and Skodaexport Praha signed a general contract for deliveries, work and technical assistance to be provided by the Soviet side for the construction of the V-1 power station.

In accordance with these fundamental documents, Czechoslovak and Soviet organizations carried out all of the preparation, construction and startup of the V-1 power stations.

Preparation for Construction and Supplier-Purchaser Relations

The basic assignment of responsibility for deliveries for the V-1 power station was planned and the division of planning labor agreed upon in accordance with the principles stated in the Intergovernmental Agreement and the general contract. The Soviet planning organization LOTEP [Leningrad Branch of Teploenergoproyekt] developed the technical plan for the power station with the participation of the Czechoslovak general designer, Energoprojekt Praha, and then developed the performance plans for the facilities in the primary section. Energoprojekt Praha worked out the first stage of the plan in the form in which it was included in the Overall Planning Design in accordance with FMTIR [Federal Ministry of Technical and Investment Development] Directive No 3/71 (DOV [POV]*, budgetary and economic sections) and the construction performance plans for the facilities. This participation by planning organizations using different organizational forms and different degrees of detail in their documentation led to complex situations in the suppliers' preparations and in performance of the work, owing to differences in the technical content and scope of the plans, different planning practices, and different sets of standards and regulations.

These difficulties had practical consequences in the initial stages of construction of the facilities in the primary section of the power station, when the construction contractor used not only a translation, but a considerable number of revisions of the Soviet plans to bring them into accord with Czechoslovak practice. Ultimately it was possible to minimize these requirements only in areas covered by mutual agreement. A new assignment of equipment deliveries at the end of 1973 made it necessary to revise the agreed-upon overall planning design, and this made it necessary to postpone the deadlines initially established for presentation of the planning documentation. To assure that construction work could proceed, the planning documentation was divided into stages, which allowed smooth construction work, but created great difficulties in preparation and coordination for all construction participants.

In developing the planning documentation, considerable use was made of the newest tested findings and experience from the operation of similar VVER power units. The plans for the power station also made use of several distinctive, progressive approaches which took account of the circumstances, for example location of the boron facilities in the lower parts of the main power production unit, revised layouts of some auxiliary circuits, and some other variations in the equipment which increased nuclear safety and operating reliability.

The development of the site layout plan for the V-1 power station in Jaslovske Bohunice made allowance for its relationship to the A-1 power station, which was completed during the period of preparations for the V-1 station.

The siting of the V-1 power station close to the A-1 station had a favorable effect during preparation and initial construction work, but also led to certain problems involving interconnections and conflicts in the underground and above-ground roadways and mains. The development of the site plan for the V-1 focused on optimal layout for the already-existing A-1 station.

*[POV: construction organization plan]

Among the main positive factors involved in the construction of the V-1 power station in Jaslovske Bohunice were the following:

--during construction it was possible to use some of the construction site facilities and permanent facilities of the A-1 power station, particularly during the first stage of construction;

--some use was made of the results of geological surveys;

--there was no change in the health protection zone and it was not necessary to remove any structures or resettle people, which also speeded up the process of securing approval from the social and legal bodies;

--the supplier organizations, particularly for the construction work, changed over without a break to work assignments on the V-1, which decreased the time required for the commencement of construction on the main power production unit;

--the experience of the investor and operator collectives could be used in the preparation, construction and startup of the power station.

Even though the Czechoslovak organizations that took part in the construction had acquired a certain amount of experience during construction of the A-1 power station, the construction of the V-1 station required that they master new construction procedures and construction organization. For this reason, difficulties were encountered in securing approval of the organization plan and construction schedules. The initial construction schedule was worked out by the general designer with the participation of the contractors and the investor and took account of findings and experience regarding the construction process and arrangement of scheduling milestones obtained in the construction of nuclear power stations in the Soviet Union, Bulgaria and East Germany.

It must, however, be stressed that the conditions under which nuclear power stations have been built in these countries are not met in the construction of the V-1 power station, i.e. number of workers, work in shifts, availability machinery, conditional and compulsory investment and the like.

Disagreements in supplier-purchaser relationships and in making arrangements for the provision of certain special products and work were among the reasons that the construction organization plan was approved only in 1974 and that compulsory adherence to the revised network chart was instituted in 1975 during full-scale construction. The use of the network chart in the management process by contractors was not, however, fully carried through because of insufficient technical and personnel preparation and because of a shortage of initial technical and scheduling information throughout the period of construction.

Accordingly, in the concluding stages of construction partial time schedules and deadlines for certain installations were worked out for the day-to-day management system, but these were based on the approved network chart.

Supplier-purchaser relations for the construction of the V-1 power station were designated by the CSSR Government Decree No 195/70 and revised by CSSR Government Decree No 149/73.

--The general leadership of Slovenske energeticke podniky [Slovak Power Production Enterprises] in Bratislava, and later Investicna vystavba energetiki Slovenska [Slovak Investment Company of Power Industry Construction] k.n.o. in Bratislava, were designated as the direct investor organization;

--The general designer was Energoprojekt Praha.

--The general construction contractor was the Hydrostav national enterprise in Bratislava, with its suppliers Armabeton Praha, Termostav Bratislava, Hutne Montaze [Metal Installation] Ostrava and Pozemne stavy [Surface Construction] Trnava.

--The general equipment contractor for the secondary section and for installation of the equipment in the primary section was the Skoda regional enterprise in Plzen, with its final suppliers EZ [Electrical Machinery Assembly Plant] Praha, Potrubi [Piping] Praha, ZPA [Machinery and Automation Plants] Bratislava, Sigma Modranske strojirny [Modra Machinery Works], Sigma Hranice, Chemont Brno, Janka Radotin, CKD [Ceskomoravska-Kolben-Danek] Praha, Termostav Bratislava, CKD Dukla Praha and others.

--The contractor for equipment from the Soviet Union and for the services of Soviet organizations was PZO [Foreign Trade Enterprise] Skodaexport Praha.

--Atomove elektrarne [Nuclear Power Stations] Bohunice was the contractor for startup of the power station and its operator.

The relations between the individual contractors and the investors were specified in economic agreements, and their work was carried out in accordance with the basic construction documents in accordance with Notice No 157/1976 of FMTIR concerning conditions governing the performance of work on the project.

The Construction Process

The construction of the power plant began while the main construction documents were being developed, following the working out and approval of the necessary performance documentation. After the essential minimum of preparation work was completed in 1972 (laying of the mains for the A-1 power plant, laying of the drainage system and the like), excavations for the main power production unit began in April 1973, in addition to which construction work was begun on the other facilities of the power station and on construction site facilities. The initial progress of construction was considerably influenced by the design of the foundations for the main power production unit)boron equipment, reactor pit) by the lateness and quantity of documentation presented and by the production of prefabricated construction and equipment components for the lower parts of the construction. The construction process was carried out in terms of the principal nodes on the time schedule; during construction there were refinements and changes were made, primarily because of changes in construction procedures and equipment delivery contingencies. In 1975, when construction was already under way on a large scale, the subsequent progress of construction work in the reactor facility was worked out in coordination with Soviet specialists, with reference to the operating conditions for the 250-metric-ton crane, which was used to install heavy process equipment; the network chart was updated to take account of this change.

Main Stages in Construction of the V-1 Power Station

	Unit 1	Unit 2
Beginning of preparatory work	25 April 1972	
Beginning of excavations for main power production unit	24 April 1973	
Structures ready for installation of steel structural members of main power production unit	October 1974	
250-ton crane put into operation	June 1976	
Large-dimension equipment installed in planned locations		
Steam generators	August 1976	November 1977
Reactor vessel	July 1977	June 1979

Stages of Testing

	Unit 1	Unit 2
Pressure and tightness tests	26 May 1978	28 August 1979
Hot tests	12 September 1978	28 December 1979
Beginning of physical startup	6 November 1978	21 February 1980
Phasing into power system	17 December 1978	26 March 1980
Comprehensive testing	27-30 March 1979	23-26 May 1980

Because of their large scope and complexity and the increased quality and precision requirements, the construction work on the installations of the main power production unit and the building housing the auxiliary facilities required the use of new, advanced procedures. The construction contractor, Hydrostav Bratislava, used certain progressive methods, processes and procedures in the construction of the power plant, which both increased labor quality and productivity and made it possible to avoid the shortages of certain specialized trades and to shorten the duration of construction work. These involved, in particular, the use of systems of steel and large-area paneling, support members, and shaped sheet metal as replacements for paneling, prefabricated partition walls which did not require plastering, wall facings made of foam concrete panels, the production of carbon steel and stainless steel facings using semiautomatic and automatic welding units, and so on.

Some parts of the construction, in which the quality and precision requirements exceeded construction norms currently in force and which constituted specialized construction work (the ponds and the reactor pit) involved considerable technical and construction difficulties.

To master the high technical requirements in accordance with plan, it was necessary to use specially chosen materials, and special methods of installation and welding in cooperation with the Welding Research Institute and specialized organizations, which led to great organizational, time and financial demands. The specifications for the physical and power-production startups required that the construction and installation work in the primary section of the power station be entirely completed. Accordingly, at the conclusion of construction work, during the startup state, it became necessary to carry out extensive construction finishing work (painting, floors, low-voltage wiring, detail work and the like) in an unusually short time, concurrently with installation work and startup work.

In spite of technical and organizational problems and insufficient capacities during construction, the structural part of work on the V-1 power station was successfully carried out, as regards both level of work and schedules.

The installation work on the V-1 power plant can be divided into three sections:

--installation of machinery and process equipment for the primary circuit and auxiliary systems,

--installation of electrical, measuring and control facilities,

--installation of the turbine room and auxiliary facilities.

The installation work on the primary circuit was carried out by Czechoslovak organizations under the general coordination of Soviet specialists. This equipment was installed in a relatively short time. The progress of installation of electrical equipment and SKR [reactor control systems] was affected by behind-schedule readying of the machinery and by modification of the equipment delivered from abroad in accordance with Czechoslovak state standards, which meant that a large amount of work piled up in a relatively short time span. Accordingly it was necessary to use a system of coordinated installation by multiple trades. The installation of the turbine room and auxiliary facilities was carried out by the classical contractor method.

A special effort was made during construction, installation and commissioning of the power station to bring products delivered from abroad into agreement with Czechoslovak standards and regulations.

Discrepancies had to be resolved by securing individual exceptions for the Office of Standards and Measurement, or by modifying the equipment, including development of the necessary documentation. But this involved considerable work and in the last of the stages of construction listed above it entailed further demands on specialized technical supplier capacities. Considerable work and assistance in these activities was provided by the operator, the Elektrarne Bohunice [Bohunice Power Stations] concern.

On the basis of the requirements for nuclear safety and operating reliability, selected equipment from the primary section was subjected to incoming tests during the course of construction. For this purpose, a plan was worked out for the testing of equipment for the power station, including incoming, pre-operation and in-operation testing to determine its condition; this plan was approved by the relevant Czechoslovak and Soviet organizations. Incoming tests were performed out jointly by the investor and specialized teams from the Nuclear Power Station Research Institute [VUJE] in Jaslovske Bohunice and Skoda Plzen. Results and experience obtained confirm the necessity and justifiability of this testing, but in the future it will be necessary to create the necessary material and technical base and to allocate a specific time span on the work schedule for the performance of these activities.

A factor that affected the progress of construction and installation work was the making of changes and additions to plans throughout the construction process. These changes and additions resulted from development of performance plans for process equipment and from attempts to use the most recent findings, particularly with regard to increased operating reliability.

To support installation work and the startup stage for unit 2, for which a relatively short time span was available, maximum use was made of experience and findings obtained in Unit 1, measures to increase coordination of work were developed, worker initiatives were offered, a continuous work cycle was introduced, the number of plan oversight personnel and review and test engineers was increased, and representatives of state oversight organizations were constantly at work on the site. In many installation operations and testing stages on Unit 2, the time required was considerably shortened while maintaining the required quality and completeness of installation. Performance of these measures also made it possible to decrease the time required for the program of physical and power-production startup and for preparations for the comprehensive testing of Unit 2.

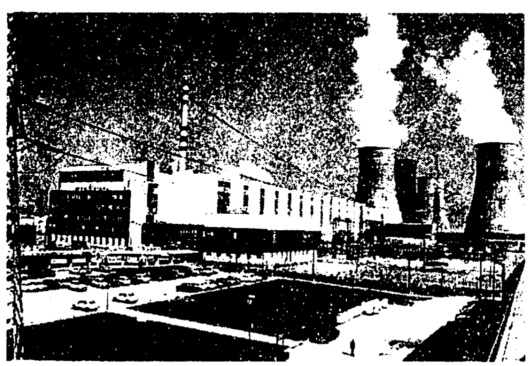


Fig. 1. General view of the V-1 power station

Management of Construction and Startup Work

The general document governing construction was the network chart, whose milestones and target dates for the different units were in agreement with government decrees. The network chart was updated annually and was used as the starting point in working out annual schedules and investment plans which specified the material and financial figures for construction and the performance contingencies and schedules.

For day-to-day management and coordination of the construction process, a "Construction Project Leadership" was created; this working body consisting of representatives of the main organizations involved in construction. For further day-to-day coordination of the progress of construction of the critical facilities, coordinating groups were created; these, under the guidance of the investor and with the cooperation of the parties involved, coordinated the progress of construction in terms of the basic and short-term network charts.

For the startup stage, the Interdepartmental Startup Committee (MSK) was organized; its executive bodies were the startup management group for Unit 1 and the operational staff and operational group for Unit 2. In the startup stage, the basic mission was to provide all management levels with the necessary support, with priority and on an extraordinary basis, for smooth performance of the concluding stage of production. This mission was supported and asserted by the operational staff and the MSK, which monitored, evaluated and approved all stages of startup work, especially in terms of the maintenance of maximum quality and operating reliability. The operational staff and operational group directly managed the progress of individual types of work in the concluding stage, and developed and approved readiness certification for sub-steps and stages of work; the activities of the other management and coordination organs were subordinated to this activity.

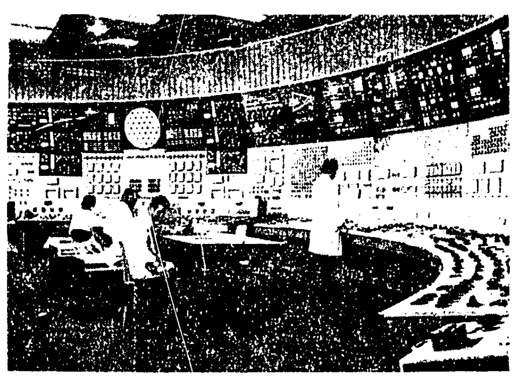


Fig. 2. The Unit Control Room

Czechoslovak-Soviet Cooperation in the Construction Work

Cooperation between Soviet and Czechoslovak organizations in accordance with the intergovernmental agreement began during preparation for the construction of the V-1 power station and increased throughout the construction work and startup. The participation and cooperation of Soviet organizations was focused on the following areas:

--preplanning and planning preparation,

--deliveries of process equipment for the primary section (reactor, steam generators, circulating pumps, primary circuit piping, volume compensator, diesel generator station equipment, protective systems, control and measurement equipment and the like),

--technical guidance of installation, installation coordination work, special installation and consultations,

--startup of the power station and training of the operating personnel,

--delivery of the nuclear fuel for operation of the power station.

The basic economic relationships were established in contracts between P20 Skodaexport in Prague and Atomenergoeksport in Moscow.

To support the production process, the structure and scope of Soviet specialists' participation in the technical guidance of installation work, installation coordination and special installation for equipment in the primary section of the power station and for the startup of the station were agreed upon by the Soviet side. Individual groups of Soviet specialists, the number of whom reached 150 at the peak, worked on a subcontract basis for the main construction participants: the investor, Energoprojekt, Skoda Plzen, and Atomove elektrarny [Nuclear Power Stations] Bohunice.

It should be stressed that this close cooperation between Czechoslovak and Soviet specialists was the basic factor in achieving successful results both in construction work and in the startup and initial operation of the power station.

Conclusion

In this article we have presented the investor's viewpoint on certain findings and problems associated with the construction of the V-1 power station in Jaslovske Bohunice. In making an overall evaluation of the construction process we may stress certain other aspects that had a positive effect on it:

--the priority assigned to the project in the state plan and its observance at the individual management levels in construction work, production and installation;

--special-capability collectives from organizations participating in construction, and good labor organization using new forms of coordination (working and coordinating groups);

--extensive use of advanced components and procedures in construction;

--a high degree of organization of startup work, with the operator organization taking a considerable part in the startup stage;

--close cooperation and participation by Soviet specialists throughout the building of the power station;

--effective use of mass political work, socialist competition and other forms of worker initiative in the construction process (international brigades);

--progressive creation of suitable labor and social conditions and services for construction workers;

--constant support from party organs and bodies of the state construction problems office.

The utilization of findings and experience from this construction work in combination with experience obtained at other power stations which have been built in the CEMA member countries will make a major contribution to further increasing the efficiency and decreasing the duration of construction work and to supporting the program for developing nuclear power in Czechoslovakia which is being carried out in close cooperation with the Soviet Union.

The experience obtained in the process of building the V-1 power station has already been used in the preparation and construction of the V-2 power station at Jaslovske Bohunice, whose conception and technical design, based on a higher level of nuclear safety, involve greater demands than the preparation and building of the V-1 power station as regards both construction and equipment, and have been used as the basis for the technical design and preparation for the construction of the Mochovce power station.

8480
CSO: 5100/3019

FINAL STAGE OF CONSTRUCTION WORK ON V-1 POWER STATION DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 pp 137-140

[Article by Jozef Keher, CSSR Deputy Minister for Technical and Investment Development: "Commissioning of the V-1 and Management of Final Construction Work"]

[Text] The construction of nuclear power stations is a complex, technically demanding undertaking in all aspects, which makes great demands on investment funds and capacities, while the construction work involves a special responsibility toward society. In the 1970's, Czechoslovakia began the construction of commercially tested nuclear power stations of the VVER 440 type. The Soviet Union functioned as supplier of the technical plans, including deliveries of the equipment making up the primary circuit, Czechoslovakia provided the plans and deliveries for the secondary circuit and the auxiliary facilities. This article gives a brief analysis of the problems of material and scheduling support of construction-installation and startup work in the concluding stage of construction. The method of managing this process in the case of the V-1 power station and its efficiency, which made it possible to put the first unit into operation within 68 months of the beginning of excavations for the main power production unit, are analyzed.

Industrial construction of nuclear power equipment takes different routes different countries. A number of factors specific to each country determine the main outlines of national technical policy on nuclear power, and especially the types of nuclear reactors used in power stations.

We developed the first heavy water reactor in the 1960's and put it into operation in 1972. The 1970's saw a change in the concept of development of Czechoslovak nuclear power production, because we began the construction of series-produced VVER-440 reactors, which had been proven in operation.

The construction of the first nuclear power plants of this type is covered by the intergovernmental agreement of 30 April 1970 between the Soviet Union and Czechoslovakia. This construction work is a component of an extensive problem* which is related to nuclear power's indispensable role in the further development of the national economy and to the development of the Czechoslovak production-technical base, particularly the power production machinery sector, which manufactures power production equipment of extraordinary size. A further problem is the need to concentrate capital construction resources and manpower on critical programs and to see that Czechoslovakia is suitably represented in bilateral and multilateral intergovernmental agreements on cooperation and specialization in equipment production, mutual provision of nuclear power equipment and scientific and technical cooperation.

The construction of the V-1 power station in Jaslovske Bohunice was begun and is proceeding in the context of this problem, but subject to material and time limitations. If we wish to analyze the problems of commissioning the V-1, i.e. of the concluding stage, which make use of the preceding critical stage, i.e. performance of the capital construction itself (beginning with planning work, and continuing with production of the equipment and performance of the installation and construction work), we must give a partial summary of it.

In March 1970 the Presidium of the CSSR Government agreed to the construction of a nuclear power station with a capacity of 880 MW consisting of two VVER-440 model V-230 units. Subsequent decrees designated the main measures to be taken in support of construction and established the schedules for commissioning the units.

In the course of the preplanning and planning preparation, when the supplier system was being created, there were considerable shortfalls as a result of incompletely worked out supplier-purchaser relations--that frequent oblique expression which negatively characterizes Czechoslovak capital construction. There occurred changes in the assignment of deliveries and technical designs and many changes in the construction performance plans (particularly the location of the boron facilities under the reactor room and changes in the "racks" [? for electrical equipment]). By 1 October 1974, only 7.6 percent of budgeted funds had been spent, and 30 percent of planning work, 32 percent of construction work and 25 percent of delivery and installation of process equipment had been completed.

These circumstances created the danger of a shortfall in meeting final deadlines estimated at about 24 months. Efforts to bring about a turn for the better resulted in a confirmation of the construction network chart by all participants at the VHJ and ministry levels in May 1975.

In the subsequent course of construction, in spite of gradual improvement, the results of insufficient provision of construction-installation and equipment production capacities, the postponement of deliveries of foreign equipment, and changes in technical design made themselves felt, necessitating further updating of the network chart and changes in the construction milestones, but nonetheless we must consider the May 1975 network chart as a change to a more efficient and effective solution of the problem. During construction of the V-1 power station, which was built using extremely complex purchaser-supplier relationships, but also with a certain amount of good experience from the construction of a complex nuclear power project, the A-1 power station, nonetheless there was a repetition of errors and problems, which manifested themselves primarily as critical time losses in the period of investor preparation and especially planning preparation and as a failure to settle supplier-purchase relationships. The undeniable newness and complexity of this type of construction were objective causes. In addition, changes resulting from stepped-up of nuclear safety weakened our capability to use experience from previous projects.

Difficulties were also created by differing methods of planning, by the use of Czechoslovak state standards, and by their relationships to the standards and technical specifications according to which equipment is produced and delivered by the Soviet Union. These problems can be solved in a positive manner only by a rational approach on the part of all construction participants, i.e. by teamwork under the leadership of the investor and systematic, skilled cooperation between the general designer and the contractors for construction, installation and startup work.

To achieve maximum coordination between the organizations taking part in the construction of a nuclear power station and to assure fulfillment of assignments as they arise at all management levels, the Federal Ministry of Fuels and Power appointed the Interdepartmental Startup Commission for the V-1 power station (MSK) by agreement with the relevant ministers.

The MSK functioned as a collective body composed of deputy ministers, representatives of the state oversight organs and responsible representatives of enterprises, led by the Deputy Minister for Investment, Ministry of Fuels and Power. Leading Soviet specialists also took part in its work.

The main tasks of the MSK were:

--to approve the most important startup programs,

--to grant permission for commencement of the key stages of startup on the basis of documents attesting that the equipment and operating personnel were ready and with the agreement of the oversight bodies,

--to solve major technical and organizational problems,

--to designate measures aimed at assuring adherence to schedules.

To see that tasks were carried out at the construction site and to exercise day-to-day leadership, the Startup Management Group was created and designated the representative of the MSK. The Startup Management Group (SRS) consisted of leading staff members of the investor, operator and contractor organizations. Soviet specialists also took part in its work.

The main tasks of the SRS were:

--to specify approaches and approve specific procedures,

--to settle technical questions arising from the startup plan,

--to validate documents certifying that equipment and operating sets were ready for each of the startup stages,

--to discuss and approve the results of tests,

--on the basis of testing results from the preceding stages and approved certifications of the readiness of equipment and personnel, to submit recommendations that the Interdepartmental Startup Commission agree to the commencement of subsequent stages.

The SRS performed its functions by means of working groups created for the most important systems in the power station (scientific leadership, primary circuit, secondary circuit, electrical, measuring and regulating equipment, dosimetry and air engineering, special purification and the like). The working groups were composed of staff members from the operator, contractor and investment organizations.

The main tasks of the working groups were:

--to make sure that the systems and equipment were complete and ready for tests,

--to produce reports on the readiness of systems and equipment,

--to develop programs of work,

--to conduct tests,

--to formulate conclusions based on evaluation of the tests,

--to rest operating personnel.

The progress of startup work was carefully monitored by the Czechoslovak Atomic Energy Commission, the Slovak Office of Labor Safety, the SSR Chief Public Health Officer and the Kraj Public Health Station in Bratislava. Their designation as oversight bodies and their tasks in the testing process stemmed from the relevant Czechoslovak laws and notices and from their own by-laws.

Even though in management terms this situation at the construction site was intolerable and uncontrollable at all levels from the management group down to the working group, it did prove possible to master the situation by means of rational approaches on the part of the construction participants, the help given by the ministries, the active assistance of Soviet specialists, and particularly their guidance. A particularly useful and helpful role in these complex relationships was played by the investor organization, which successfully mastered a situation stemming from recent changes: a technical design was accepted which in many cases had to be carried out in a short time span, even though it was frequently not possible to work out the technical documentation supporting it and no one knew how deliveries were to be assured.

This indicates that much can be accomplished by an extraordinary approach and especially by commitment, but this requires extraordinary efforts and an extreme degree of coordination and leads to increased expenditures; ultimately, however, it shortens the deadlines for the performance of finishing work in the period when the project becomes the most complex and encounters the highest demands for work quality. This must be backed up by the results of tests in the individual stages, such as incoming tests of selected process equipment, circulation flushing, pressure tests of the primary and secondary circuits, initial tests of the electrical, measuring and regulation equipment, hot tests, the physical and power production startups and their associated experiments, final comprehensive operation and test operation.

Each of these phases involves a number of new, but also recurring, problems, which very often resulted from insufficient coordination of the planning documentation;

this manifested itself to a critical degree in incorrect relationships between the primary circuit (Soviet performance plan) and the secondary section (Czechoslovak deliveries and performance plan).

An especially important item in the first half of 1978 was the problem of use of the Czechoslovak state standards and their reconciliation with equipment delivered from abroad, where the knowledge of the material problems and a correct design approach on the part of engineers and staff members of the state oversight bodies and the state Office of Standards and Measurements made it possible to find a way of solving the problem with surprising ease. In some cases additional modifications were made on equipment that had been delivered, and in some instances exceptions were adopted, but with adherence to and maintenance of the main conditions for equipment operating safety and personnel safety.

The critical tests before agreement to begin physical startup of the first block could be secured were the hot tests, which are tests of the process equipment as a complex under nonradioactive conditions. These tests had to be interrupted because of defects in coordination between the functions of the primary and secondary sections. It took almost 2 weeks of continuous work to revise the performance plans for the electrical and automation equipment on-site and necessitated the direct cooperation of designers, installers and startup workers.

In the first stage of the power production startup, during the experiments and during operation, the following main problems and shortcomings emerged:

--The performance plan for the electrical, measuring and regulating equipment was not adequately coordinated, which resulted in many problems in the concluding stage of the tests. These problems were solved through extraordinary measures by a multidisciplinary group composed of designers, installers and test engineers on-site.

--The general contractor for equipment and the final suppliers failed to coordinate the overall startup process for the secondary section at a level adequate for startup. A particularly noticeable shortcoming emerged in providing process interconnections and relations between operating conditions in the individual operating sets, which unnecessarily complicated testing and prolonged the work. In the secondary circuit of a nuclear power station, it is insufficient to use an approach similar to that used for conventional thermal power stations. The general contractor for equipment did not create the conditions for overall coordination in preparation for comprehensive testing in continuous operation. This coordination was achieved only with reference to the particular operating set being tested. There was no comprehensive management element (which might consist of the shift engineer and other necessary workers on the shift) with a comprehensive knowledge of operating problems in the secondary section and their relationship to the primary circuit. These functions had to be provided collectively by a startup group from Atomove elektrarre and Soviet specialists.

--The first trail run of the secondary section revealed certain shortcomings of design concept:

a. The condensers were filled with demineralized water through only one pipe other than the sprayer, which made it impossible to make up losses during operation or other condensate losses (resolved for the moment by a temporary hookup).

b. The coolant flow for the feedwater pump gland is connected to the demineralized water makup line, and there was a water pressure drop in the pump shutoff unit: a brief pulse-type pressure drop was sufficient to shut off the feedwater pumps. With this design, the operation of the feedwater pumps was unreliable.

c. The shutoff mechanisms monitoring water levels in the steam generators require sensitive regulation in about a 7-cm range. A brief dynamic change in the water level is sufficient to shut off the turbogenerators.

d. The system of shutoff devices protecting the individual machines and equipment was overdimensioned and did not allow for the higher priority given to operating condition requirements for the reactor and the primary circuit.

e. A basis for reliable diagnosis of emergency conditions by multiple sensors and subsequent actuation of the shutoff devices by selection of, say, 2 out of 3 sensors, was not always observed for the shutoff and protective devices.

f. Components of high reliability and quality were not always chosen in Czechoslovak-supplied monitoring, regulating and electrical equipment (even for auxiliary equipment).

--The automatic regulating systems could not be adjusted by the date set for trial of the turbines. It was necessary to put these systems into operation during the first running-up to the various power output levels. It is impossible to run both turibnes without automatic regulation.

Major problems arose in the adjustment of the automatic regulating system for the following reasons:

a. the regulators were prototypes and proved to have problems,

b. the supplier did not have a sufficient number of spare parts,

c. full laboratory testing and adjustment were not performed before installation.

Accordingly it was necessary to repeat the laboratory testing while the turbines were being run by the operator, to take extraordinary steps to provide the spare parts, and to arrange servicing by the producers. The defects were frequently found only by the operator, and the supplier organizations were unable to eliminate them expeditiously and assure continuous availability of their specialists during adjustments, which prolonged the process of power production startup at the 35 percent power level and made it impossible to proceed to a higher output level.

--The electrical equipment supplied proved to be unreliable in operation in some cases, and it became necessary to replace components or make additional modifications during tests. The scope of these was small, and accordingly it was possible to eliminate these problems more expeditiously than in the case of the measuring and regulating equipment.

With the exception of these problems, all participants in the construction work managed to cut their performance time, particularly in the concluding stages of construction, installation and startup work; the first unit was connected into the electrification system at the end of 1978 and its power startup was continued under conditions which led steadily to stabilization of its operation. The first unit was put into operation 68 months after the beginning of excavations for the main power production unit.

It was possible to eliminate fundamental problems which decreased operating reliability, and in the second half of 1979 the unit operated in the power system with quite different, more favorable results.

My survey and analysis of the problems might perhaps seem to be too critical and to fail to give due recognition to the quantity and quality of work done by the construction participants; but the high demands regarding the quality of nuclear power equipment and its reliability and safety cannot be measured only by the size of the expenditures, the intensity of the work and the devotion of the workers: the critical result is reliable and safe operation with optimum economy.

Construction of the second unit proceeded simultaneously with work on the first. The participants in the construction work made excellent use of the lessons learned on the first unit and dealt with their assignment well; the necessary changes in the documentation for the second unit were quickly made and higher-quality preparations were made, even though problems with deliveries were repeated in the case of the second unit. The devoted and, above all, the skillful work of construction participants, workers and engineers were a positive factor in the key stages of work on the primary circuit and the electrical, measuring and regulating equipment, and in the construction finishing work, with the result that in some cases the time requirements were decreased to as little as half that needed on the first unit, including startup and adjustment work, while the quality of all work was considerably higher. The result was a successful power-production startup and trial operation, and current fulfillment of the production plan with minimal stoppages due to malfunctions. The reactor pressure vessel in the second unit was set in the reactor pit in June 1979, and the power production startup of the block and the beginning of power production came in March 1980.

Conclusion

The construction of nuclear power stations on the planned scale and on schedule is a complex and demanding task in all respects. It can be accomplished through a fundamental improvement of investor, planning and construction preparation and by better management of all aspects of the work. Special account must be taken of the following circumstances:

--The rapid development of technical designs subsequently leads to running changes in the planning documentation not only in repeated construction of VVER-440 units, but especially in the construction of the first VVER-1000 units.

--The development of the production and technical base for nuclear power equipment and the construction of nuclear power stations constitutes the main structural transformation of the Czechoslovak power machinery industry as regards quality (industrial utilization of nuclear technology) and the extent of capacities, resources and manpower taking part in these changes.

--The material and social complexity of this process is intensified by the coexisting demanding situation in the national economy, particularly in capital construction, as a result of which the priority of nuclear power plant construction must be continually asserted in planning, construction and installation work and the production of equipment, which leads to increased demands on capacities.

This circumstance shows itself particularly in the difficulty experienced in meeting established deadlines for commissioning of individual units and in the need to take constant action, even in the central economic and political leadership, to assure that the nuclear power stations are built. The further expansion of nuclear power plant construction requires:

--Discussion by central organizations of the current organizational arrangements and the management level that has been achieved as they relate to the scale of nuclear power station construction through 1990, including the necessary amount of work in progress, and to existing regulations on capital construction, so as to achieve greater centralization of management, greater integration of the activities of the various trades, unambiguous and inescapable designation of the production participants' responsibilities, and a considerable simplification of supplier-purchaser relations. The measures which emerge from this discussion should be implemented, even by the economic organizations. Finally, the process of managing preparation and performance should be developed to the point of optimal integration and centralization of nuclear power plant capital construction.

8480
CSO: 5100/3019

QUALITY CONTROL PROCEDURES FOR V-1 EQUIPMENT DESCRIBED

Prague JADERNA ENERGIE in Slovak No 4, Apr 81 pp 140-143

[Article by Miroslav Herman, VUJE [Research Institute of Nuclear Power], Jaslovske Bohunice: "Incoming and Pre-Operation Tests of Materials in Selected Equipment for the V-1 Power Station"]

[Text] This article describes the system for assuring the quality of materials used in selected equipment for Units 1 and 2 of the V-1 power station in Bohunice during incoming and pre-operation tests. It covers the main findings emerging from this process, including a description of organization for the testing work and a description of the methods and test procedures used.

1. Introduction

An important factor in assuring nuclear safety is assurance of the integrity of materials in selected equipment in the primary circuits of nuclear power units. To meet these requirements, during construction of the V-1 power station in Bohunice a set of nondestructive flaw detection tests of the basic materials and the weld materials and weld overlays in the most important equipment of the primary circuits of Units 1 and 2 were carried out. Below we describe the approaches to testing, the procedures themselves, and the ways of evaluating the results.

2. The Testing System

Work related to the testing of selected equipment for the V-1 power station began on the basis of an FMPE [Federal Ministry of Fuels and Power] Decree of 29 July 1975. The scientific research base of Atomove elektrarne [Nuclear Power Stations] Bohunice developed a draft program for testing activity which was issued under the title "Testing Plan for Selected Equipment of the V-1 Power Station." After extensive comment, the draft was adopted in August 1976 as a document specifying:

--the choice of nuclear power equipment to be included in the category of "selected" equipment,

--organizational support of preparatory and testing work,

--requirements regarding the testing methods themselves,

--the locations, extent, schedules and methods of testing the materials,

--criteria for evaluating the quality of the materials.

In terms of time, the tests were distributed among the installation stage (incoming tests), the startup stage (pre-operation tests) and the permanent operation stage (operating tests) for each unit.

2.1 The Purposes of Incoming and Operating Tests of Selected Equipment

The purpose of incoming tests of the selected equipment was to check the quality of the material and the welded joints of the equipment when it was delivered by the producer. This assured that all unacceptable defects were eliminated at the test points before installation. The group of selected equipment for Units 1 and 2 of the V-2 power station included the functionally most important elements of the primary circuits. These were: the reactor set, the Js500 main circulation piping and volume compensator piping, the main gate valves for the Js500 piping, the hydraulic sections of the main circulating pumps, the steam generators and volume compensator, the special water purification fitters and the bubbler tank of the volume compensator.

Pre-operation tests of the condition of the material were carried out on the same equipment as was subjected to incoming tests. Their purposes were:

--to check the quality of installation of the equipment in assemblies which were critical to the integrity of the primary circuit,

--to determine the initial, zero-point condition of the material in the equipment for the purpose of periodic operating tests.

As the foregoing indicates, incoming and pre-operation tests, and especially their results, constitute a precondition for the decision to begin the physical startup of a unit.

The bulk of the testing in these stages was carried out at the V-1 power station by the Federal Ministry of Fuels and Power's testing laboratory in the Research Institute of Nuclear Power [VUJE], Bohunice. The organization responsible for state oversight over nuclear safety and stage specialized oversight over labor safety was the investor, represented by plant No 01 of the k.u.o. Investicna vystavba energetiky Slovenska [Slovak Investment Company for Power Construction] in the case of incoming tests, and the operator of the V-1 power station, Atomove elektrarne Bohunice, in the case of pre-operation tests.

At peak intensity, 35 members of the ministry's testing laboratory in VUJE and 15 members of cooperating organizations were taking part in the testing.

3. Organization of the Testing

Responsible persons from the investor organization and the research laboratory in VUJE were entrusted with organizational support for incoming testing. Their tasks were:

--preparation of the equipment for tests,

--performance and evaluation of the tests, and where necessary the making of repairs and repetition of the tests.

VUJE worked out more detailed programs for incoming tests, since it was the principal counterpart of the supplier in securing approval of the tests.

The tests themselves were carried out in accordance with deadlines in the time schedule for complete construction of Units 1 and 2 with the required quality. Because pre-operation tests were carried out during the first and second reviews of the equipment in the units during the startup period, the preparation for these tests was much more demanding than that for incoming tests. Accordingly, detailed work schedules were developed, and the occasion was taken to solve the problem of performing construction and installation finishing work, preparation of equipment for functional and material tests, performance of the reviews, and preparation of the equipment for the next stage of startup.

During the first and second reviews of the units, two working groups consisting of representatives of the operator, its maintenance and quality control subdivisions, the investor organization, the equipment supplier and the materials testing organization were created; in accordance with the relevant schedules for startup work, these organizations coordinated:

--preparation of the equipment for testing and review,

--testing, evaluation of the tests, and elimination of defects where necessary,

--preparation of the equipment for the next stage of startup work,

--performance of final installation, construction and insulation work.

Responsible representatives of the Soviet supplier and members of the Soviet startup group took part in both working groups.

It speaks well of the work of these groups that the deadlines established for the performance of the tests were completely met. This confirms that they were correctly chosen and that the experience obtained in performing them could be applied in the construction of subsequent units.

4. Incoming Tests of Materials and Welds in Selected Equipment

We should note by way of introduction that the incoming tests of the material of selected equipment for Unit 1 of the V-1 power station were the first action in the process of assuring the quality of nuclear power equipment for use in commercial nuclear power stations in Czechoslovakia. It follows from this that support work and the testing itself involved extensive preparatory discussions and demanding organizational work.

4.1 Scope and Methods of Testing and Evaluation

The scope of the incoming tests, involving designation of test locations and percentage of items to be tested was so chosen for each procedure that tests would be made of the quality of:

--the majority of production welds in the equipment,

--selected surfaces of the material used in manufacture,

--most of the surfaces of corrosion-resistant overlays,

--surface on which installation welds would be made,

--connection pieces on the equipment,

--characteristic dimensions of certain pieces of equipment.

During the performance of the incoming tests, their initial scope was changed as a result of the test results. For example, selective ultrasonic testing of the material of the Js500 main circulation piping and volume compensator piping was replaced by 100-percent testing, and selective testing of certain welds on the main circulating pumps by overheating was also replaced by 100-percent testing; the testing of the main gate valves for the Js500 tubing was expanded to include overheating of the material in the central casting, and so on.

Direct visual inspection accounted for the largest percentage of the test methods, while ultrasonic and overheating methods accounted for about equal proportions of the volume methods, and of the surface methods the capillary method was applied only to austenitic materials, while only the magnetic powder method was used for other materials. If defects were found, all possible methods were used to identify them precisely.

For testing of dimensions we used measuring devices capable of giving the required degree of precision. The Rockwell method was used to measure hardness. The extent of the ferromagnetic phase in austenitic materials was determined by the eddy current method.

Structural analyzes of the materials at selected locations were carried out by non-destructive metallography using the impression method. Mechanical tests which would have given a complete picture of the quality the materials were lacking; they could not be performed because test samples of the material were not provided with the equipment.

The tests were carried out using instruments and materials which were good by international standards: equipment of proven quality recommended by the Czechoslovak Flaw Detection Center was used. VUJE developed its own equipment for identifying the positions of austenitic welds and preparing the surfaces of materials for the taking of impressions.

For visual inspection of the inner surfaces of reactor control system tubing and other inaccessible surfaces of the equipment inside the reactor, Skoda Plzen developed a manipulator which could maneuver a television camera by remote control.

The results of nondestructive testing of welds and overlays were evaluated in accordance with the "Regulations for Testing Welds and Overlays in Assemblies and Structural Members of Nuclear Power Stations, Experimental and Research Nuclear Reactors, and Sets," PK 1514-72.

The quality of the material used was evaluated in terms of the producer's technical specifications for each type of equipment selected. Instances in which defects exceeded acceptable standards were resolved by a special approach. As part of this approach the Czechoslovak side always developed an expert judgment, in the production of which research organizations in the materials, welding and nondestructive testing fields participated. Minor defects were dealt with as they occurred by the simpler approach of repair in situ.

The other characteristics tested (e.g. hardness, characteristic dimensions) were compared with the figures in the technical documentation sent with the equipment.

5. Pre-Operation Tests of the Condition of Materials and Welds of Selected Equipment

The program of pre-operation testing in Unit 1 of the V-1 power station was demanding because of the concurrent performance of final installation work in the areas where the tests were being made. The situation was much more favorable on Unit 2 owing to the status of finishing work.

5.1 Scope and Methods of Testing and Evaluation

The scope and methods of pre-operation testing were worked out in the "Plan for Testing of Selected Equipment for the V-1 Power Station" mentioned above.

The scope of pre-operation testing was so chosen that the results and findings would provide complete starting data for periodic operating tests. In addition, the quality of installation work was monitored in assemblies which were important in assuring the integrity of the primary circuit.

The test methods were chosen so that they could be repeated during in-operation tests. Among volume testing methods, the amount of testing by overheating was minimized and the amount of testing of the material of the reactor pressure vessel was adapted to the capabilities of the manipulator used or the concrete container.

During the test work, several manipulators developed by VUJE and Skoda for operating tests were themselves tested. They included the TELEKAR manipulator for carrying a television camera during inspection of the interior surfaces of the main circulating piping and a modernized manipulator for remote visual inspection of the interior surfaces of SOR [? protective system] piping by television.

One shortcoming was the fact that there were no tests of a manipulator which would allow remote visual and ultrasonic testing of the reactor pressure vessel, a manipulator for remote visual inspection of the inner surfaces of the primary steam generator collectors and one for inspecting the inner surfaces of the volume compensator pressure vessel, all of which were already available at the time of the first and second operating tests on the equipment. During pre-operation testing of the reactor pressure vessel, however, an equipment set and procedure for ultrasonic testing corresponding to the equipment set of the Swedish TRC company's inserted manipulator were applied.

In pre-operation testing, the problem of separating test operations from various stages of startup work arose to a greater extent than in incoming tests.

As part of pre-operating testing of Unit 1, during the first and second reviews the whole range of test operations prescribed by the testing plan was repeated.

After comparison of results from the two sets of tests performed on Unit 1 and consideration of breakdown mechanisms, the following set of test operations was drafted and used on Unit 2:

a. The first stage of pre-operation tests was carried out after the pressure test of the secondary side of the steam generators and consisted of testing of:

--the pressure vessel of the steam generator, from outside,

--the steam collector of the steam generator.

b. The second stage of pre-operation tests was carried out after the first and second hydraulic tests of the equipment as part of the first review and included testing of:

--the installation welds of reactor connections to the main circulation piping,

--the inner weld overlays of the reactor pressure vessel,

--the installation welds on the main circulation piping and the volume compensator piping,

--the nuts and bolts in the primary collectors of the steam generators,

--the outside of the volume compensator.

c. The third stage of pre-operation tests was carried out after the third hydraulic test of the equipment as part of the second review and included tests of:

--the interior surfaces of the steam generator pressure vessels, including the nuts and bolts of themanholes,

--the steam generator primary circuit collectors, including tightness tests of the tube plates,

--the interior of the volume compensator pressure vessel and other selected equipment tc the full extent prescribed in the testing plan.

This division of pre-operation testing into three stages helped decrease the time required for testing during the first and second reviews and helped make possible smooth performance of insulation work on the selected equipment.

The results of nondestructive testing were evaluated in terms of the same principles as were used in incoming testing.

6. The System for Preparing Documentation, Document Storage, and Machine Processing

The evaluation of test results were worked up into partial records which contained all data required for subsequent tests, and also reported the test evaluations.

Annexes to the documents gave identification data on the position and nature of acceptable defects which were found and data on the number, nature, position and means of elimination of unacceptable defects.

The results of the individual tests reported in the partial records were aggregated into final records for each piece of equipment. These forms also contained suggestions for subsequent installation or startup work.

All of the documents are stored by the investor's or operator's relevant subdivision and by the ministry's testing laboratory in VUJE.

To make efficient use of this documentation, VUJE developed and tested a system for machine processing of the quality documentation.

7. Conclusion

Now that the units of the V-1 power station have been successfully put into operation, we may state that the aims established for assuring the quality of materials in selected equipment have been met. We should, however, note again that this was the first performance of a demanding program in this field, which required effort not only directly in the testing process, but also in the preparations for these operations, in working out the test programs and the like. The fact that all of the planned measures were carried out was also the result of a considerable amount of active cooperation by the investor, the operator and the research organizations which were involved. Thus Czechoslovakia has created a base for the performance of demanding tasks to assure the quality of other nuclear power stations with VVER 440 units which will be built.

8480
CSO: 5100/3019

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000400060013-7

STARTUP OF V-1 POWER STATION DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 pp 143-148

[Article by Viliam Ziman, Dominik Carnecki, Vladimir Tvaroska and Vincent Capicik, Atomove elektrarne [Nuclear Power Stations] Jaslovske Bohunice: "The Startup of the V-1 Power Station"]

[Text] This article describes the temporal and material aspects of startup work on Units 1 and 2 of the V-1 nuclear power station, with particular reference to work on the primary circuit from the flushing and pressure tests on the equipment to the power production startup and 72-hour comprehensive testing of the power station.

1. Introduction

Startup work on a nuclear power station is the concluding stage of its construction in which the equipment is put in order (broken in) and the individual machines and functional systems are tested. A large amount of startup work (breaking-in and testing) was performed concurrently with installation. The testing of the individual elements or functional systems is carried out together with that of the relevant electrical equipment and measuring and regulating equipment (MaR). The nuclear safety work which is done during the startup stage as a specific requirement for the startup and operation of a nuclear power station may be divided into (1) the work leading up to introduction of the nuclear fuel, i.e. the nonradioactive tests, and (2) the period following introduction of the fuel into the reactor, i.e. the radioactive tests.

The following procedure was used in startup and breaking-in work:

--Nonradioactive tests:

1. Flush, pressure resistance and tightness tests of process systems (including the first hydraulic test,

2. Pressure tests and circulation flushing of primary circuit (second hydraulic test),

3. First review,

4. Hot tests (third hydraulic test)

5. Second review.

--Radioactive tests:

1. Physical startup,

2, Power production startup

3. 72-hour comprehensive trial.

The main purposes of the nonradioactive tests are:

--achieving the required cleanliness of the inner surfaces of piping and equipment,

--checking the strength and tightness of the installed piping and equipment,

--testing the quality and completeness of installation of this equipment,

--testing the operability of the systems and equipment in conditions similar to those of actual operation,

--measuring the real parameters and characteristics and testing the operating modes and interactions of the equipment and systems, and comparing them with the design figures.

--acquisition of skills and experience by operating personnel,

--checking overall readiness for introduction of fuel.

The aims of the radioactive tests are:

--experimental determination of the operating physical characteristics inside the core,

--testing the operation of the power station in normal, transition and emergency conditions,

--bringing the power station to the rated output.

In the preparatory phase it was necessary to work up and evaluate the startup documentation. We evaluated a one-stage working draft, on the basis of which we developed standard programs of startup work on the individual process units and for the main stages of startup. On the basis of these programs we worked out the operational programs which took account of the specific status of installation and startup work. A total of 178 operational programs were developed for the nonradioactive tests in the two units.

2. Organizing Final Installation Work and Commissioning of the Unit

Startup work on the primary circuit with its auxiliary systems and equipment was performed by staff members of EBO [Bohunice Electric Power Stations] with extensive participation by Soviet startup personnel. Startup work on the systems and equipment designed by the Czechoslovak side was performed by the Skoda regional enterprise through its suppliers.

Each of the main stages in the startup work requires a certain degree of readiness of the process equipment and structures, so that final construction and installation work proceeded in parallel with the startup work. When Unit 2 was put into operation, there also arose the requirement of maintaining safe operation of Unit 1, which was already functioning.

The complexity of the task required close coordination of startup and breaking-in work. Accordingly we adopted the following startup management organization (we give the organization used for Unit 2). The operations staff supported and was responsible for technical management of all final construction and installation work and for startup in accordance with the startup schedule.

The construction project leadership created the conditions for material and time fulfillment of the startup schedule for Unit 2 and arranged and supported economic activity during final construction and installation work and startup, and decided on and carried out economic activities.

The operations group represented the executive and--through its working groups--the performance arm for the decisions and orders of the operations staff. It represented the technical, process and coordination leadership of the working groups.

The working groups developed operational programs and schedules for performance and completion of the specific tasks within the schedules established by decisions of the operations staff and operations group. They saw to the performance of construction-installation, startup and break-in work by all trades.

Working groups made up of representatives of participating organizations, i.e. IVES [Slovak Investment Company for Power Construction], Soviet Specialists, EGP [Energoprijekt], the Skoda regional enterprise, Hydrostav and EBO were created for:

--the process water system,

--the 110-kV switchgear for in-plant power supply,

--in-plant power consumption and "racks" [? for electrical equipment],

--the control room for the unit, the relay panels, the measuring and regulating equipment, and the secondary section,

--primary circuit auxiliary systems,

--the primary circuit itself,

--the turbine room and central pumping station,

--the diesel generator station,

--air engineering.

A scientific leadership group for startup, with representatives from EBO, VUJE and CSKAE [Czechoslovak Atomic Energy Commission] was created to manage the preparation and performance of the physical and power production startup programs.

To limit unnecessary manipulations and to assure labor safety, starting with the beginning of the circulation flushing it was necessary to institute a special labor organization regime in the main power production unit. Conditions were created for controlled access to the primary circuit areas, and operation in continuous shifts was begun. All activities in the main power production unit were subordinated to startup and break-in work.

3. Flush, Pressure and Tightness Tests of the Process Systems

The process systems were flushed out with demineralized water at a speed of 2 to 3 m/sec so as to remove installation dirt, welding overflows and extraneous objects from the inner surfaces. Demineralized water in the required quantities and of the required quality was provided by the chemical water treatment facilities of the V-1 or A-1 plant. The piping in the process water system was flushed with process water fed by VD-400 pumps in the central pumping station. Systems with a gaseous working medium were blown out with compressed air. Systems with temporary loops were rinsed in two ways: first with the temporary diverters installed, followed by a second circulation rinsing of the loops in their planned final configuration. Changes of water were also made at the same time, as needed. After the flush, the water was drained to the outside water drainage system, since it contained no chemical reagents.

The flushing process was monitored in terms of the quality of the flush water. When 95 percent transmittance was reached, the flushing was terminated.

After the flushing was complete, the unnecessary temporary diverters were removed and the process units which were already in their planned configurations were subjected to pressure and tightness tests. One of the most important pressure tests is that carried out on the various loops of the primary circuit. Successful performance of this test makes it possible to begin partial emplacement of the insulation and also decreases the likelihood that the pressure tests of the primary circuit before circulation flushing will last excessively long. In the first unit, the loops were put under pressure one by one with the normal makeup pumps. The greatest degree of leakage was shown by the flange joints of the self-contained circuits in the main circulating pumps. All cases of leakage found were immediately corrected. During strength tests of the loops in Unit 2 considerably less leakage was found, and this fact, in combination with the performance of simultaneous pressure tests of all the loops, considerably decreased the time consumed in the tests.

4. Circulation Flushing of the Primary Circuit

The flushing of the inner surfaces of the primary circuit was carried out with circulating water heated to 160°. The heating and circulation of the water were carried out by the main circulating pumps. It is extremely important for the performance of this testing stage that certain systems in the secondary section be in good operating condition:

--the water heating system,

--the feed water equipment,

--the primary circuit cooling system.

The main objectives in this stage are:

--to test the tightness of the primary circuit,

--to finish testing the welds for compliance with the standards for putting the primary circuit into operation,

--testing several operating regimes,

--first startup of the main circulating pumps,

--removal of installation dirt from the primary circuit and attainment of a water purity in the primary circuit which meets the standards,

--testing the combined operation of systems and equipment.

The circulation flushing of the primary circuit can be divided into several substages:

--filling the primary circuit with water of the requisite quality,

--pressure tests at 3.5 MPa,

--creation of a nitrogen cushion and heating of the primary circuit to 120° C,

--strength tests of the primary circuit at 17.5 MPa,

--heating the primary circuit to 160° C,

--circulation flushing at 160° and 4 MPa, and water change,

--cooling the primary circuit to 40°-50° C and draining it.

In addition to monitoring the operation of the main auxiliary equipment and systems, the following work was also done during the circulation flushing:

--monitoring and measuring the heat expansion and displacement of primary circuit equipment,

--the secondary stage of removal of protective coatings and passivation of the secondary side of the steam generator,

--tensometric measurements in Unit 1, used to test the computation procedure used in the design of the compensation system.

In Unit 1, the hydraulic resistance of the core was simulated by partially covering the openings in the reactor support housing. A baffle was installed in the separating ring of the reactor pressure vessel, thus separating the hot and cold legs of the loops. A "long loop," allowing circulation of the primary circuit water and replacing the hydraulic resistance of the core, was created by disassembling the hydraulic section, of the main circulating pumps on loops 4 and 5.

The primary circuit was heated by operating the second and third main circulating pumps; the temperature rise was 4°-6° per hour. The heating was speeded up by heating the steam generator with feed water. Later the water change line was subjected to circulation flushing simultaneously with removal of the protective coating from the steam generator. In both units of the V-1, the required water quality in the primary circuit was attained as soon as the protective coating had been removed from the steam generators. After satisfactory results had been obtained for the steam generators, the circulation flushing was terminated and cooling was begun.

5. First Review of the Equipment

The content of the first review of the equipment was:

--evaluation of the state of the equipment after hydraulic tests and circulation flushing,

--evaluation of the reliability of the main and auxiliary equipment of the primary circuit,

--elimination of all defects and malfunctions found during the circulation flushing,

--introduction of dummy fuel elements into the core,

--installation and sealing of the reactor.

After cooling the primary circuit to 50° C and draining it, it was possible to proceed with:

--checking the condition of the equipment in the primary circuit (use of nondestructive methods to test the quality of the metal in equipment and piping, evaluation of the condition of seating and sealing surfaces as well as other interior surfaces),

--evaluating the quality of the rinsing done on the interior surfaces of the primary circuit piping and equipment,

--preparing the equipment for the hot tests (introducing the simulator, fitting out and closing the reactor for the hot tests),

--elimination of problems and shortcomings in the equipment found during circulation flushing.

The main document specifying the scope and performance of nondestructive tests is the "Instructions for Pre-Operation Testing of Selected Equipment in the Bohunice V-1 Nuclear Power Station." The sequence and scope of work in the first review of the reactor are specified by EBO's working programs. In view of the fact that the support housing (barrel) and two main circulating pumps were not included in the circulation flushing of Unit 2, the work done differed from that done on Unit 1.

All surface defects such as scoring, grooves, scratches, rough spots, scoria and metal spatter which were found at the test points by nondestructive flaw detection methods were eliminated by grinding.

Final installation and construction work proceeded concurrently with this first inspection.

6. The Hot Tests

The most important stage of nonradioactive testing of the primary section of a nuclear power station is the hot tests. These include comprehensive tests of practically all systems in the reactor and turbine rooms, the operation of all electrical equipment and the measuring and regulating systems, and tests of their combined operation in conditions similar to the normal operating regime. Thus it is the last comprehensive test of the equipment before introduction of the fuel. The elimination of malfunctions and defects in the equipment does not yet involve problems of maintaining radiation safety or handling nuclear fuel.

Fig. 1. The first container of fresh fuel before its introduction into the reactor of Unit 1 at the V-1 station: a glorious moment for the joint Czechoslovak-Soviet brigade.

The hot tests themselves can be divided into five substages:

1. filling of the primary circuit, and pressure tests at 3.5 MPa,
2. heating the primary circuit to 120° C and strength testing at 17.5 MPa,
3. heating of the primary circuit to 260° C,
4. functional tests at a primary circuit temperature of 260° C,
5. cooling of the primary circuit.

The main tasks carried out during the hot tests were:

--checking the strength of the upper unit of the reactor, since the process cover was used during circulation flushing,

--determining the hydraulic characteristics of parts inside the reactor and the primary circuit,

--measuring the heat balance of the primary circuit,

--measuring the thermal expansion and displacement of the equipment,

--comprehensive tests of the reactor protection and regulation system,

--testing of the operation of the equipment in the primary circuit: the volume compensator system and its safety valves, the bubbler, the main circulating pump, the main shutoff valves, and the steam generators with their safety valves,

--individual functional tests of auxiliary systems along with the primary circuit,

--tests of turbogenerator runout,

--simulation of losses from in-plant consumption, and tests of the automatic equipment for stepwide startup,

--cooling of the primary circuit,

--acquisition of skills and experience by the operating personnel.

To stabilize the primary circuit's characteristics, the running-up of the equipment and the planned tests were begun at a primary circuit temperature of 260° C, in the following sequence:

a. The safety valves of the volume compensator were adjusted by means of auxiliary equipment produced by Simpellat a primary circuit pressure of 8 MPa. The functional tests of the bubbler and volume compensator were carried out at the end of the hot tests, with satisfactory results.

b. In adjusting the safety valves of the steam generators it was necessary to make alterations in the pressure system of the surge valves.

c. A test of the separating equipment at t_{PO} = 260° C, p_{PO} =12.5 MPa confirmed that it was operating properly.

d. A comprehensive test of the reactor regulation and protective system was made.

The purpose of this test was comprehensive adjustment and testing of the following reactor regulation and protective systems:

--the system of emergency protective devices,

--the AC and DC power supply system for the reactor regulation and protective system,

--the control system for the emergency control assembly dirves,

--the emergency control assembly drives and the ionization chamber.

The tests were made with the reactor filled but not under pressure, at a primary circuit pressure of 4 MPa, and thereafter at the rated values. Tests confirmed that all systems were operating properly.

e. The hydraulic characteristics of the primary circuit were measured.

The purpose of these measurements was to test the expected hydraulic characteristics of the system and the primary circuit equipment under operating conditions (i.e. temperature, pressure, coolant flow rate) in stationary and transitional modes. The measurements consisted of the following subtasks:

--establishing the relationship between the coolant flow rate and pressure losses in the core in stationary primary circuit operating modes,

--determination of the hydraulic resistance coefficients of the individual parts of the primary circuit in stationary modes with different numbers of main circulating pumps, and determination of the overall hydraulic characteristics of the primary circuit,

--determination of coolant back flow in the main circulating loop with the main circulating pump stopped and the main shutoff valve opened and partly opened, and determination of the relationship between the flow rate and the degree of opening of the main shutoff valve,

--measurement of the primary circuit transition characteristics with the main circulating pumps out of operation and being brought up to speed, and determination of the time dependency of coolant losses and flow in the core and the circulating loops with the main circulating pumps operating and stopped,

--testing of the coolant flow through the main circulating pump by measurement of the heat balance in steam generator No 1.

f. Measurements of heat losses to the surroundings and the heat capacity of the primary circuit were made by heating the primary circuit, with circulation being provided by different numbers of main circulating pumps. Both of these figures are essential for calculating the heat output of the reactor below 5 percent of nominal output. A knowledge of the heat capacity of the primary circuit is needed for calculations on nonstationary modes.

g. Testing and monitoring of gross temperature measurement of the coolant exiting from the fuel assemblies.

h. The measuring systems in the primary circuit were adjusted and tested.

i. Tests were made of volume compensator operation in regimes using a steam and a nitrogen cushion, of heating by the electrical heaters, of replacement of the nitrogen cushion by a steam cushion and vice versa, of the makup regime, and of piping vibration.

j. The expansion of the primary circuit was measured.

k. Functional tests were performed on the following primary circuit auxiliary systems:

--intermediate circuits of the reactor regulation and protection system and main circulating pumps,

--normal makeup,

--steam generator drainage.

l. Turbogenerator runout was tested; these tests for defects in the electrical and mechanical sections were completed in both units during the physical startup stage.

After all tests included in the hot test stage were completed, we cooled the primary circuit, checking the operation of the cooling system in all regimes.

7. The Second Review of the Equipmemt

The content and purpose of this stage were:

--evaluation of the condition of the equipment after the hot tests and elimination of any malfunctions or defects,

--final adjustment and testing of the technical transport equipment and elimination of malfunctions and defects,

--comparison of the results of the second review with results obtained during operation.

The review covered the following equipment:

--the reactor vessel,

--parts inside the reactor,

--the upper unit of the reactor,

--the outlets of the control, emergency and shim assemblies,

--the interiors of the steam generators,

--the main shutoff valves,

--the interior surfaces of the Js500 piping,

--the main circulating pumps,

--the volume compensator and electrical heaters,

--the bubbler.

Defects found during the second review were corrected.

8. Physical Startup

The content and scope of the physical startup experiments included in the program were chosen to cover all operating requirements regarding the reactor's physical characteristics. The final results of the experiments on the reactor is an ability to predict accurately its behavior in various operating modes and thus to assure safe and economical operation of the power station.

In preparation for physical startup, a step-by-step physical startup program was worked out for each unit; it covered all the work from preparation of the reactor and the other equipment for the introduction of the fuel, through the actual loading of the core and preparation of the reactor for operation, to attainment of the minimum measurable power. The time interrelations and sequence of performance of the individual experiments were worked out on a physical startup scheduling chart. The scope of tests and measurements was specified by the physical startup work programs.

To support the startup work by designating areas of activity, responsibility, authority and organizational subordination of supervisors, a set of regulations for work organization during physical startup and directives on methods of work with an open primary circuit were drafted.

The physical startup process can be divided into two parts:

1. introduction of fuel,

2. achievement of criticality and performance of the physical startup experiments themselves.

These two parts are separated by installation work connected with the sealing of the reactor.

The introduction of the fuel can be divided into four successive steps:

First stage: introduction of 37 control parts of the HRK [main control assemblies]*, Second stage: introduction of 162 fuel elements,

Third stage: introduction of 37 absorbers into the main control assemblies, and filling of the reactor with boric acid to a level 200 cm from the bottom of the core basket, i.e. 60 cm below the heads of the fuel elements,

Fourth stage: introduction of the remaining 150 working assemblies at intervals of 25, 50 and 250 cm, with time delay.

The initial critical stage is attained by decreasing the boric acid concentration with all working assemblies of the main control assemblies withdrawn. The concentration is decreased by changing water and by saturating the special water purification filters No 1.

Note: the results of the physical startup are described in detail in the article by staff members of VUJE [pp 148-154 of original].

9. The Power-Production Startup

The power-production startup is the concluidng part of startup work on a nuclear power station, which follows successful completion of the physical startup of the reactor. The power-production startup consists of gradually bringing the station up to power. During the power-production startup the functioning of the power station equipment is checked, normal operating, transitional and emergency modes are investigated, the self-regulation system is checked, the neutron-physical and heat engineering characteristics of the core are monitored and the radiation system is checked at various power levels up to 100 percent.

Experimental work in the power-production startup began with testing of the ionization chambers at a power of 5 percent of the nominal figure. At this power the station's emissions into the atmosphere are adjusted and the natural circulation is checked with various numbers of loops connected.

Then the reactor power was gradually increased to 20 percent, 35 percent, 55 percent, 75 percent, 90 percent and 100 percent of the rated figure.

The results of the power production startup in the two units fully confirmed the design figures and characteristics for the V-1 power station, the calculated values for conditions in the core, and the maintenance of radiation and nuclear safety. Above all, the tests demonstrated the reliability of the systems that assure nuclear safety of the unit:

--turbogenerator and main circulator runout,

--automatic diesel generator startup,

--functioning of the automatic equipment for stage-by-stage startup of important drive mechanisms,

--reactor shutdown and maintenance of pressure in the primary circuit.

Note: The results of the power-production startup are given in the article by the VUJE staff members [pp 148-154 in original].

10. Comprehensive 72-Hour Operating Trial

After successful completion of the power-production startup program, we completed this stage with the 72-hour comprehensive operating trials, which were successful for both units.

A comparison of the startup work for the two blocks of the V-1 power station shows that in the case of Unit 2 there was a considerable shift of available time to the stages of preparation of the equipment for the main of work (Fig. 3). The duration of the main stages was considerably shortened; for example, the circulation flushing of Unit 2 lasted 13 days, while for Unit 1 it lasted 28 days; the hot test lasted 35 days for Unit 1 and only 13 days for Unit 2. The lengthening of the first and second reviews, sometimes as a result of delivery problems, provided a sufficient time span for high-quality preparation and testing of the process equipment systems. Unit 2 experienced a minimum number of stoppages resulting from breakdowns of equipment and incorrect operations by the operating personnel.

Conclusion

In comparison with the startup of Unit 1, the time required to bring Unit 2 to 100-percent power and perform the 72-hour comprehensive operating trials was decreased by 40 days.

The results achieved in the physical and power-production startup confirmed that the main characteristics of the primary and secondary circuits were in agreement with the design figures. Measurement of the self-regulation capability confirmed that the temperature and power had a negative feedback effect on reactivity.

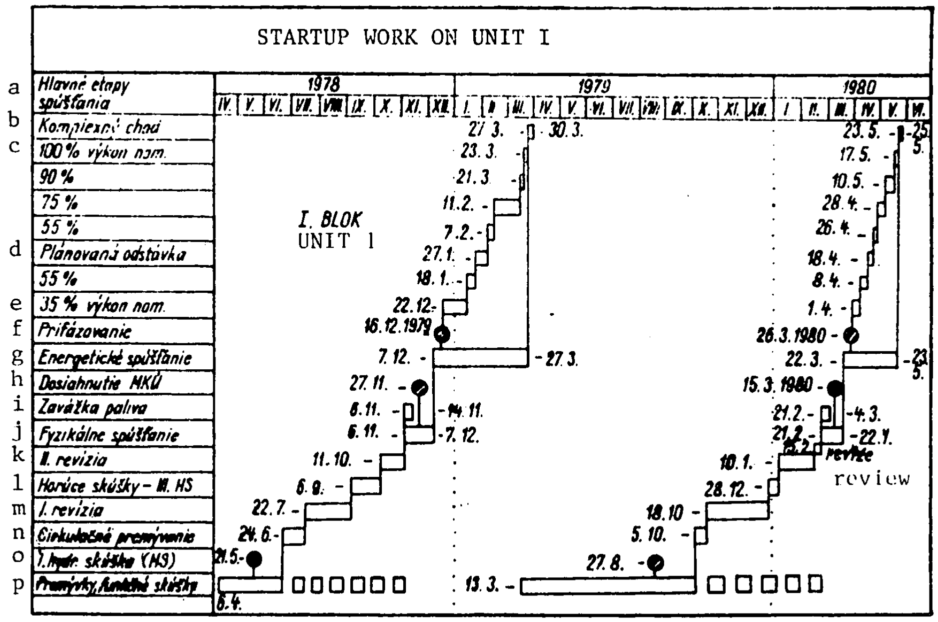
Measurements confirmed that withdrawal of heat from the core by natural circulation was sufficient to cool down the reactor in case of an emergency shutdown. Dynamic tests of the unit, during which the regulators were adjusted, were used to check correct behavior of the unit in transitional modes.

In the preparation and performance of startup work on Units 1 and 2 of the V-1 power station we obtained a good deal of valuable practical experience. Its use in the startup of subsequent units with VVER reactors is an indispensable precondition for the development of nuclear power.

BIBLIOGRAPHY

1. EBO. Technicka sprava o spustani 1. bloku JE V-1 [Technical Report on the Startup of Unit 1 of the V-1 Power Station] (Part 1).

2. EBO. Technicka sprava o spustani 2. bloku JE V-1 [Technical Report on the Startup of Unit 2 of the V-1 Power Station].



[Table 2]

Key:

a. Main stages of startup
b. Full operation
c. 100 percent of rated power
d. Planned stoppage
e. 35 percent of rated power
f. Phasing-in
g. Power-production startup
h. Attainment of minimum measurable power
i. Loading of fuel
j. Physical startup
k. Second review
l. Hot tests, 3d hydraulic test
m. First review
n. Circulation flushing
o. First hydraulic test
p. Flushing, functional tests

8480
CSO: 5100/3019

RESULTS OF PHYSICAL, POWER PRODUCTION STARTUP OF V-1 UNITS 1 AND 2 DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 pp 148-154

[Article by Stefan Kacmary, Stefan Rohar, Jozef Ricany and Ivan Sarvaic, VUJE Jaslovske Bohunice: "Results of Physical and Power Production Startup of Units 1 and 2 of the V-1 Power Station"]

[Text] This article describes the concept and performance of work during physical and power-production startup of Units 1 and 2 of the V-1 power station in Jaslovske Bohunice. It presents evaluations of the results of the most important tests performed on the units. The approach to startup work is evaluated and suggestions for startup of future VVER-type units are given.

1. Introduction

The commissioning of a nuclear power station is the last phase of its construction. After all construction and installation work has been completed and individual tests on the various pieces of equipment or partial tests of the various systems have been performed, one of the most-awaited stages of construction, namely attainment of criticality in the reactor followed by breaking-in the power station equipment, is begun. Following measurements at zero power, the output of the unit is gradually increased to the rated value, while an extensive program of tests and measurements is carried out at various power levels. The main purposes of this program can be summarized as follows:

--testing of the main neutron-physical parameters of the core;

--testing to assure that the nuclear fuel and regulating components have been correctly introduced;

--determination of the hydraulic, heat engineering and electrical characteristics of individual pieces of equipment and of the unit as a whole;

--testing of the functions of the control system, automation equipment, and shutoff and protective elements, and their adjustment;

--testing of the coordination between individual systems;

--testing of the operability of the unit in the planned range of nonstationary transition conditions (operating and emergency conditions);

--mastery of operation of the unit by operating personnel with the assistance of experienced operators.

The concept and content of the various stages of startup of the V-1 were based primarily on experience with VVER-type reactors in the Soviet Union, East Germany and Bulgaria and on advanced experience of other producers of pressurized-water power reactors.

On the basis of standard Soviet programs [1, 2] for the startup of VVER-type nuclear power stations, we developed detailed work programs for the physical and power production startup stages, which following approval became compulsory for performance of the various tests. Particular attention was devoted to development and maintenance of nuclear and process safety procedures.

During startup of the second unit of the V-1 power station, use was made of experience acquired with Unit 1, as is most strikingly indicated by a comparison of the time elapsing between introduction of the first fuel cell into the core and achievement of the planned power: this was 142 days for Unit 1 and only 93 days for Unit 2.

2. Physical Startup

The purpose of the tests included in the physical startup stage was to check the most important neutron-physical properties of the core. This stage included the following tests:

--attainment of criticality,

--monitoring control assembly function and the symmetry of loading of the core,

--checking the functioning of emergency protective devices of types I through III and determination of the efficiency of the control assemblies by means of withdrawal at temperatures of 120° and 260°,

--measuring the effectiveness of the boric acid solution and the integral and differential characteristics of the groups of control assemblies at a coolant temperature of 120° C,

--measurement of the temperature and pressure coefficients of reactivity,

--measurement of the effectiveness of the boric acid solution, the integral and differential characteristics of the control assembly groups and the temperature coefficient of reactivity at 260° C,

--calibration of the neutron flux instruments,

--measurement of the power coefficient of reactivity below 1 percent of nominal output.

During power-production startup, additional data on the temperature and power coefficients of reactivity were obtained (under reactor operating conditions); these are given below, together with the results measured in the physical startup stage.

An important part of the preparations for operation of the VVER-type nuclear reactors in Czechoslovakia was the preparation of the basic software to be used in calculating the physical parameters of the core. This consisted of adapting Soviet computer programs [3] which were further expanded, particularly in regard to microscopic parameters of cells in the assembly structure and extensive core calculations for all expected states [4]. This work was performed in cooperation with UJV [Nuclear Research Institute, CSAV] Rez, and VUJE [Research Institute of Nuclear Power Stations].

Physical tests during the breaking-in of the reactor (i.e. between the beginning of the lowering of the boric acid concentration and the attainment of a reactor heat output corresponding to about 1 percent of the planned output) were performed in 10.2 calendar days for Unit 1 and in 9.3 calendar days for Unit 2 according to a modified time schedule. In accordance with common practice for pressurized-water reactors (including the VVER), the tests were performed in two separate stages, which differed primarily by the temperature of the coolant in the reactor. For the "cold reactor" the characteristic coolant temperature was about 120° C, while for the "hot reactor" it was about 260° C; this was the case for both reactors in the V-1 power station.

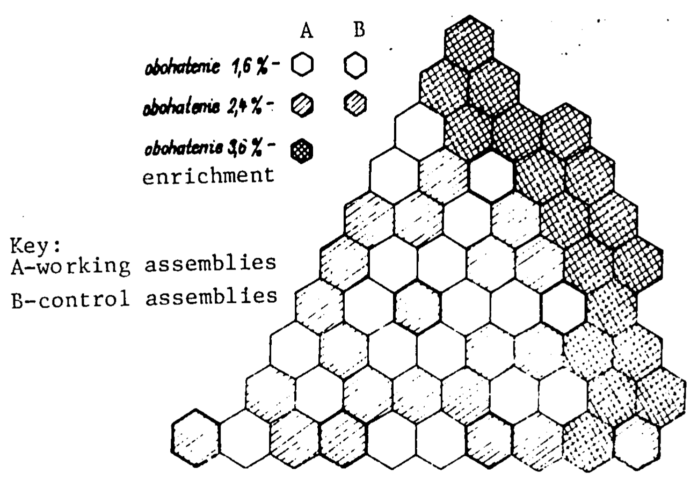


Fig. 1. Disposition of fuel the core of the V-1 power station.

Fig. 2. Distribution of the nonuniformity coefficients in the reactors of the V-1 power station.

Key: a. Usual limit of disperson of nonuniformity coefficients

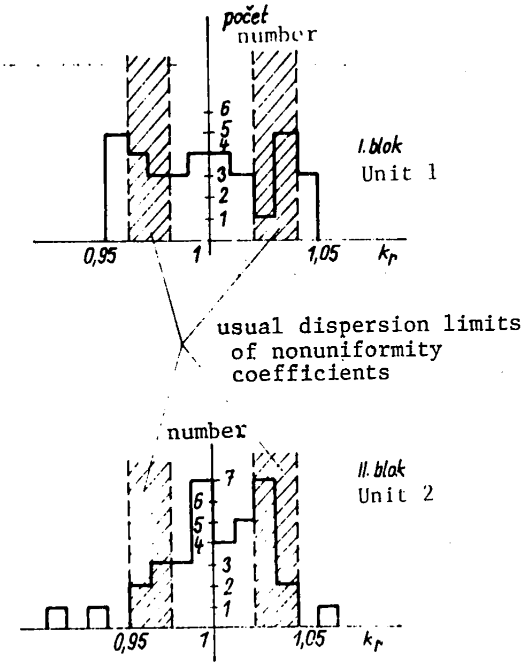


Fig. 3. Effectiveness of the sixth group of control assemblies measured at 260° C on Unit 2 of the V-1 station.

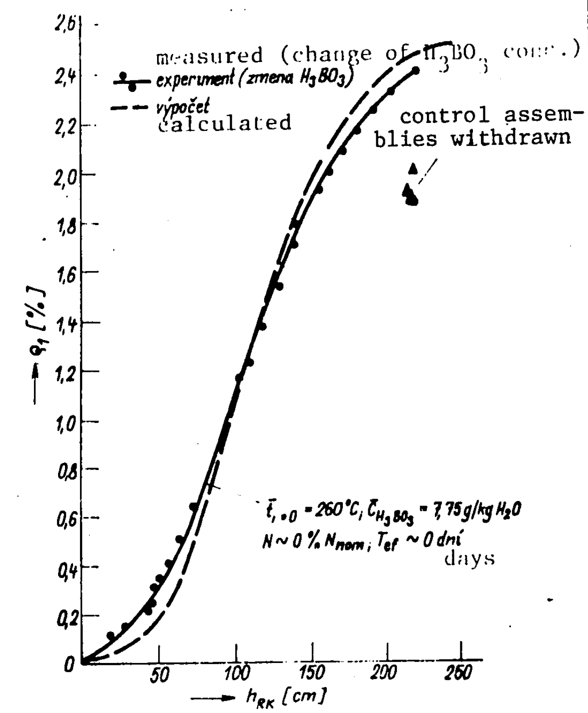


Fig. 4. Isothermal temperature coefficient of reactivity as a function of coolant temperature

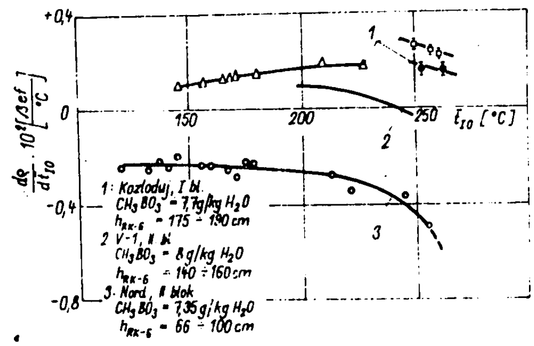


Table 1. Critical concentrations of boric acid for selected regimes.

Tabuľka 1

Kritické koncentrácie kyseliny boritej pre vybrané režimy

Unit	Position h_{RK} [cm]	$\bar{t}_{IO}$ [°C]	p_{IO} [MPa]	meas. $c^{exp}_{H_3BO_3}$ [g/kg]	calc. $c_{H_3BO_3}$ [g/kg]
V-1 Unit 1	h_{RK-6} (178)	123	12,36	7,95 ± 0,09	7,87
	h_{RK-6} (190)	261	12,16	8,00 ± 0,05	7,76
V-1 Unit 2	h_{RK-6} (192,5)	119	12,36	7,94 ± 0,16	7,85
	h_{RK-6} (49,5)	115	10,30	6,69 ± 0,11	6,62
	h_{RK-6} (209)	258	12,31	8,09 ± 0,10	7,74
	h_{RK-6} (65)	260	12,26	6,24 ± 0,1	5,87
	h_{RK-6} (24)	261	12,26	7,33 ± 0,8	6,90
	h_{RK-6} (0)	260,5	12,26	6,02 ± 0,05	5,68
Kozloduj Unit 1	h_{RK-6} (200—250)	117	—	7,7 ± 0,1	—
	h_{RK-6} (200—250)	265	—	7,9 ± 0,06	—
NORD Unit 2	h_{RK-6} (200—250)	106	—	7,80 ± 0,04	—
	h_{RK-6} (200—250)	260	—	8,00 ± 0,1	

Table 2. Integral efficiency of groups of control assemblies as a function of H_3BO_2 concentration, measured on Unit 2 of the V-1.

Tabuľka 2

Integrálna efektívnosť skupín kaziet, nameraná na 2. bloku V-1 zmenou koncentrácie H_3BO_3

$\bar{t}_{IO}$ [°C]	Position h_{RK}	$c_{H_3BO_3}$ [g/kg]	meas. $\varrho_{exp.}$ [%]	calc. $\varrho_{vyp.}$ [%]	$\bar{t}_{IO}$ [°C]	Position h_{RK}	$c_{H_3BO_3}$ [g/kg]	meas. $\varrho_{exp.}$ [%]	calc. $\varrho_{vyp.}$ [%]
116	h_{RK-6} (187 — 0) + h_{RK-5} (200 — 250)	7,70	0,95 ± ± 0,1	0,99	260	h_{RK-6} (0 — 222) + h_{RK-5} (200 — 250)	7,75	1,72 ± ± 0,2	1,85
	h_{RK-6} (187 — 0) + h_{RK-5} + h_{RK-4} (200 — 250)	7,45	1,17 ± ± 0,1	1,22		h_{RK-6} (0 — 222) + h_{RK-5} + h_{RK-4} (200 — 250)	7,60	2,17 ± ± 0,2	2,35
	h_{RK-6} (187 — 0) + h_{RK-5} + h_{RK-4} (50 — 200)	6,60	2,73 ± ± 0,2	2,62		h_{RK-6} (0 — 222) + h_{RK-5} + h_{RK-4} + h_{RK-3} (200 — 250)	6,90	4,38 ± ± 0,39	4,57

Table 3. Comparison of the effectiveness of the sixth group of control assemblies (0-250° C), measured with changing H_3BO_3 concentration.

Tabuľka 3

Porovnanie účinnosti VI. skupiny regulačných kaziet (0—250 cm) nameranej zmenou koncentrácie H_3BO_3

Unit			V-1 unit 1	V-1 unit 2	Kozloduj 1	NORD 2
Cold reactor	Efficiency (%)	measured	1,09* ± 0,02	1,12*	1,14 ± 0,03	1,10 ± 0,03
		calc.	1,08	1,09	—	—
	Temperature (°C)		120	116	117	106
Hot reactor	Efficiency (%)	measured	1,75*	1,77*	1,8 ± 0,03	1,81 ± 0,03
		calc.	1,89	1,89	—	—
	Temperature, °C		260	260	265	260

* Hodnoty prepočítané na plné zasunutie

*Converted to values for fully-removed rods.

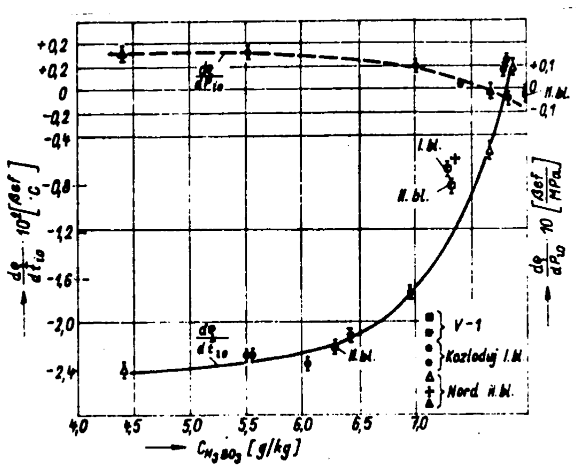


Fig. 5. Mean isothermal temperature coefficient of reactivity (250-260° C) and temperature coefficient of reactivity as a function of boric acid concentration in primary circuit coolant.

Fig. 6. Temperature coefficient of reactivity of the moderator in various reactor output states for Units 1 and 2 of the V-1.

Key: FS--physical startup;
ES--power-production startup

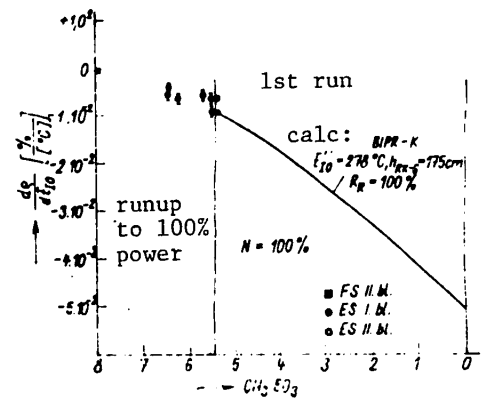


Table 4. Overall effectiveness of control devices of the reactors in Units 1 and 2 of the V-1 power station, measured during physical startup.

Tabulka 4

Celková efektívnosť regulačných orgánov reaktorov 1. a 2. bloku JE V-1 nameraná pri fyzikálnom spúšťaní

Unit/datum	Unit 1	Unit 2	Calculated BIPR-5	Reactor rm. tech. plan 43484	V-1 safety report
Cold reactor: total reactivity (%)	9,5 ± 0,15	11,47 ± 0,2	9,67	9,6	—
Hot reactor: total reactivity (%)	12,46 ± 0,3	13,1 ± 0,3	11,9	12,4	10,5

Table 5. Effectiveness of boric acid, measured during physical startup of Unit 2 of the V-1 power station.

Tabulka 5

Efektívnosť kyseliny boritej, nameraná pri FS 2. bloku JE V-1

$\bar{t}_{TO}$ [°C]	Position h_{RK} [cm]	$\Delta\rho/\Delta c$ [% kg H_2O/g H_3BO_3] measured	calc.
116	h_{RK-4} (200 → 0) h_{RK-4} (200) → h_{RK-4} (50)	—2,14 ± 0,15 —2,20 ± 0,17	—2,2
260	h_{RK-4} (200 → 0) h_{RK-4} (200) → h_{RK-4} (50)	—2,01 ± 0,18 —2,02 ± 0,15	—2,0

The measured values were evaluated in the final reports [5, 6]; below we give the most important of them in comparison with the results measured in the reactors of Kozloduj Unit 1 and NORD Unit 2 [7]. The cores in these units had the same charges of nuclear fuel (Fig. 1). The calculated values were obtained by use of the BIPR-5 and BIPR-K computer programs.

The critical concentrations of boric acid measured in the cold and hot reactors are shown in Table 1. Small deviations from the figures measured at Kozloduj Unit 1 and NORD Unit 2 are related to tolerances in uranium enrichment and in the weight of the fuel cells, and to systematic errors in measurement of the boric acid concentration.

Measurements on V-1 Units 1 and 2 (Fig. 2) gave higher power nonuniformity values that are usual in VVER-type reactors [7]. A computational analysis showed that interchange of fuel cells with different degrees of enrichment would give substantially higher nonuniformities than were measured in V-1 Units 1 and 2, so that the higher nonuniformity of volume power distribution could be ascribed to experimental error. To decrease the nonuniformity of the volume distribution of power, when charging Unit 2 the approach of allowing for production deviations in weight and degree of enrichment of the uranium in the delivered fuel cells [8] was adopted.

The integral and differential characteristics of the control assemblies were measured by varying the boric acid concentration. The time characteristic of reactivity found by using a computer to solve the kinetic equations was processed by the KINETIK program in such a way that a linear regression line was entered on the reactivity chart between two movements of the control rods. This method eliminates reactivity fluctuations resulting from random fluctuations of the neutron flux and also to some extent from spatial effects. The measured integral effectiveness values for V-1 Unit 2 are given in Table 2. Table 3 compares the effectiveness of the sixth control assembly group for different blocks. The integral characteristics of the sixth group for the hot reactor is also given in Fig. 3.

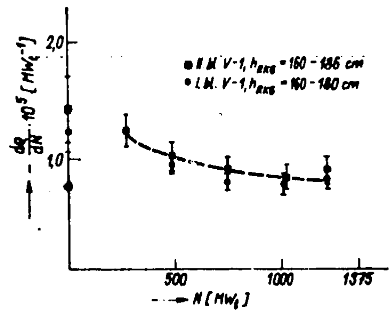
The overall effectiveness of the entire system of control assemblies in terms of neutron flux resulting from withdrawal of the control rods differs by approximately 7 to 10 percent from the computed values (see Table 4). The effectiveness of the boric acid, expressed as the boric acid reactivity coefficient ($\Delta\rho / \Delta c$) is given in Table 5 as a function of the position of the control assemblies.

The isothermal temperature coefficient obtained during heating of the reactor is shown in Table 4 and the isothermal temperature coefficient measured as the boric acid concentration in the coolant was lowered (with the control assemblies withdrawn) is given in Fig. 5).

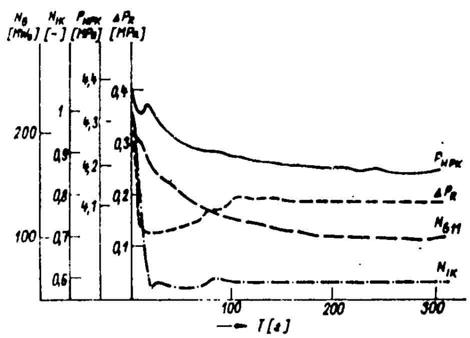
The temperature coefficient of reactivity of the moderator, obtained through kinetic measurements in various power production states of the reactor [5] with the control assemblies in operating position, is one of the most important reactor characteristics. Fig. 6 gives the measurement results obtained during gradual increase of reactor power; for full reactor power, the figure also shows the calculated curve for this coefficient during the course of the run.

The power feedback coefficient, also measured by the kinetic method [9], is shown in Fig. 7. The results measured in both units of the V-1 power station are in agreement with each other and in good agreement with the results obtained for NORD Unit 2.

Fig. 7. Power coefficient of reactivity as a function of reactor power with constant coolant exit temperature.



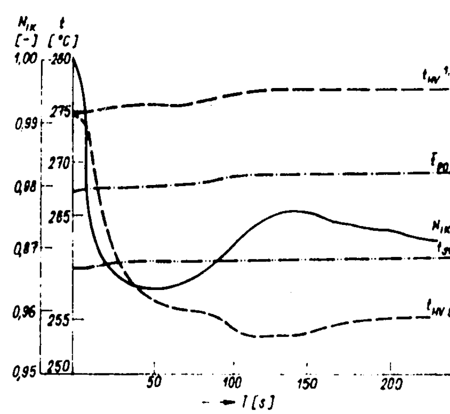
Obr. 7. Závislosť výkonového koeficienta reaktivity na výkone reaktora pri konštantnej vstupnej teplote chladiva



Obr. 8. Výpadok HCČ 2. a 5. $N_R = 100$ %, 1. blok

Fig. 8. Main circulating pumps 2 and 5 out of action, N_R = 100 percent, Unit 1.

Fig. 9. Main circulating pump 1 out of action, self regulation. N_R = 55 percent, Unit 1.



Obr. 9. Výpadok 1 HCČ — samoregulácia. $N_R = 55$ % 1. blok

3. Power-Production Startup

After successful conclusion of the physical startup tests and preliminary evaluation, the power-production startup stage began, and the reactor output was gradually increased to 5, 20, 35, 55, 75, 90 and 100 percent of the nominal power. At each of these power levels, combinations of the following measurements or tests were performed on both units in accordance with the startup schedule:

--measurement of the hydraulic characteristics of the primary circuit,

--measurement of the heat balance and calibration of the power measuring instruments,

--tests of self-regulation of the reactor and the unit,

--calibration of the temperature measuring sensors in the primary circuit,

--monitoring of the heat production field in the core,

--testing of reactor cooling in the natural circulation mode,

--tests of mechanical runout of the turbogenerators,

--tests of the system for automatic regulation of stations for release of steam to the condenser and the atmosphere,

--tests and adjustment of turbine and reactor power regulators,

--tests of the operation of emergency protective signals of types III and IV as a function of operating parameters,

--tests of in-house power supply systems,

--tests of coordination between the main regulators in the unit (dynamic tests),

--tests of the tightness of sealing of the fuel elements,

--measurement of the radiation situation during power production startup.

The results of these measurements and tests are too extensive to be presented in this article. They are evaluated in detail in references 10 and 11. For purposes of illustration we give the results of the main tests during operation of the unit. In addition, we include results from tests of the behavior of the unit in transitional processes resulting from cessation of operation of the main process equipment; for safety of operation these must be passed without the unit's dropping out of operation or emergency shutdown of the reactor. The importance of these tests is underlined by the fact that they are used to investigate situations which might arise at any moment during operation. The purposes of these tests are:

--overall testing of the reactor and turbine regulators,

--acquisition of data for correction of the main regulators in the unit,

--determinations of limits and conditions for operation of reactor equipment at various power levels,

--testing of the design dynamic characteristics during emergency disconnection of the main equipment in the unit.

A graphic overview of the behavior of the most important parameters during certain selected tests is given in Figs. 8-12.

The curves for the main unit parameters indicate that the main protective regulators and automation equipment regulators successfully deal with transition processes after adjustment, even in case of dropout of all important equipment in the unit, while maintaining unit safety.

Performance of the tests and measurements on V-1 Units 1 and 2 provided a good deal of practical experience which must be used fully when commissioning future nuclear power stations. Here we cite only the most important:

a. In terms of the number of VVER-type nuclear reactors that have been operated, the program of tests may be considered standard. It is part of the comprehensive testing of the functional operability of the unit before it is put into test operation, with simultaneous determination of the characteristics which are essential for further operation. A number of these characteristics cannot be determined during regular operation using the standard set of equipment.

b. The established program of tests and the conditions for their performance must be unconditionally adhered to. An attempt to shorten the program of tests may lead to the loss of certain characteristics, and it is not possible to rely entirely on characteristics measured on other units because of the differences between the characteristics of individual pieces of equipment. Similarly, it is impossible to recommend shortening the program of tests and measurements by not adhering to the conditions for the tests themselves.

c. In carrying out the tests it is necessary to observe unconditionally the full range of parameter changes called for by the plan. Experience shows that during startup there is a tendency to decrease the number of parameter changes so as to decrease the number of equipment shutdowns in the unit. The range of parameter changes is chosen so that one of the most important aims will be met, namely identification and elimination of defects.

d. To assure smooth performance of the tests which are part of physical and power-production startup, it is necessary to assure high quality of the measuring equipment. In both units of the V-1 power station, an RPP-16 S computer was used to collect and preprocess the results. It may be stated that the use of computers considerably improved the quality of the information on processes that flows to operating and testing personnel, considerably decreased the number of experiments required and speeded up evaluation of the tests on which transition to a higher output level depended.

e. From the point of view of startup of future power station units, it will be necessary to devote more attention to the period of preparation for comprehensive testing and to individual and partial tests of the equipment and systems, so that the systems will operate reliably during physical and power production startup, which ultimately will yield greater success by shortening the time required to bring the power station to its rated power.

4. Conclusion

A comparison of the test results and the characteristic curves produced from them during physical and power production startup of Units 1 and 2 of the V-1 power station with the planned and calculated values for these units shows good agreement. Similarly, we may state that there is good agreement with the results of startup work in similar units with VVER reactors. Discrepancies between calculated and measured values were noted during measurements on the control rods in the hot reactor. Since similar discrepancies were noted for both blocks of the V-1 it is probable that it resulted from insufficient correlation of the input constants for the IPR computation program. The discrepancies between the calculated and measured power coefficients of reactivity were judged acceptable in Czechoslovakia and East Germany, and additional correlation of the BIPR computer program was performed on the basis of these results.

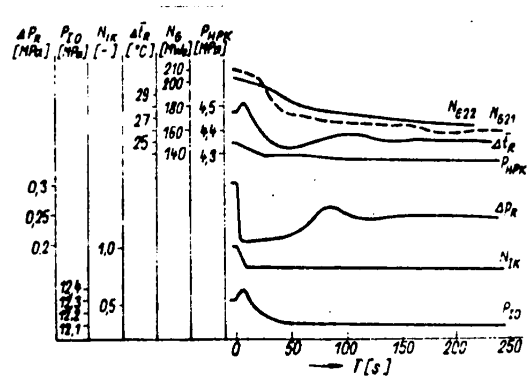
Valuable practical experience was obtained during preparation for and performance of the physical and power-production startups. Its use in subsequent units will lead to further imporvement of the quality of collection and evaluation of measurement data and thus to further refinement of the computer program. This fact will also help to establish more precisely the limits and conditions governing operation, which ultimately will yield improved operating safety while allowing an upgrading of the technical and economic parameters of the units.

In addition, during physical and power-production startup, the reliability of the protective, safety and regulating systems was demonstrated, making possible reliable operation of the first Czechoslovak commercial nuclear reactor as part of the power system. These conclusions have been fully borne out by subsequent power-production operation of both blocks.

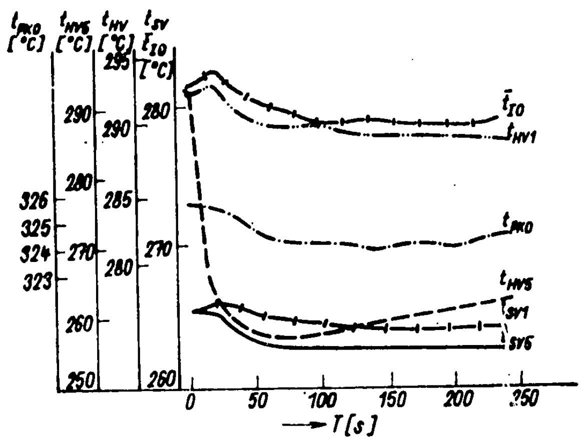
List of Abbreviations

$C_{H_3BO_3}$	Boric acid concentration
G_{DPO}	Quantity added
h_{RK}	Position of control assemblies
h_{PG}	Water level in steam generator
h_{PS}	Degree of opening of exhaust stations
N_t	Heat output of reactor
N_{IK}	Heat output of reactor according to ionization chembers

a

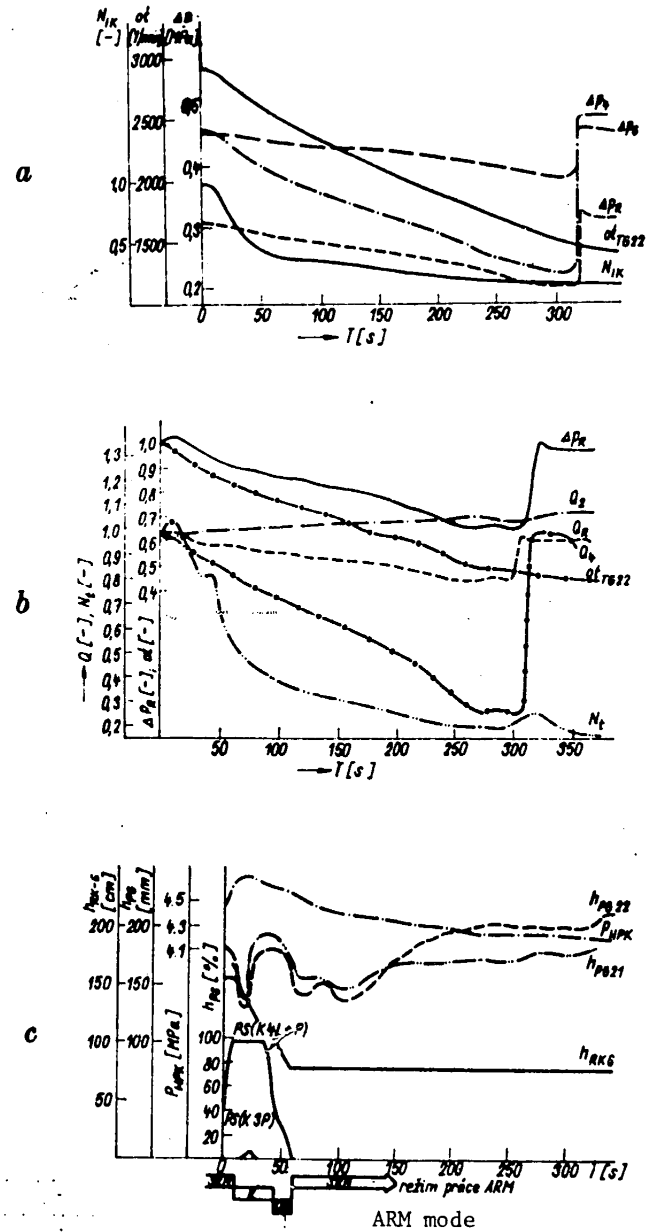


b



Obr. 10a, b. Výpadok HCČ 5. N_R = 100 %, 2. blok

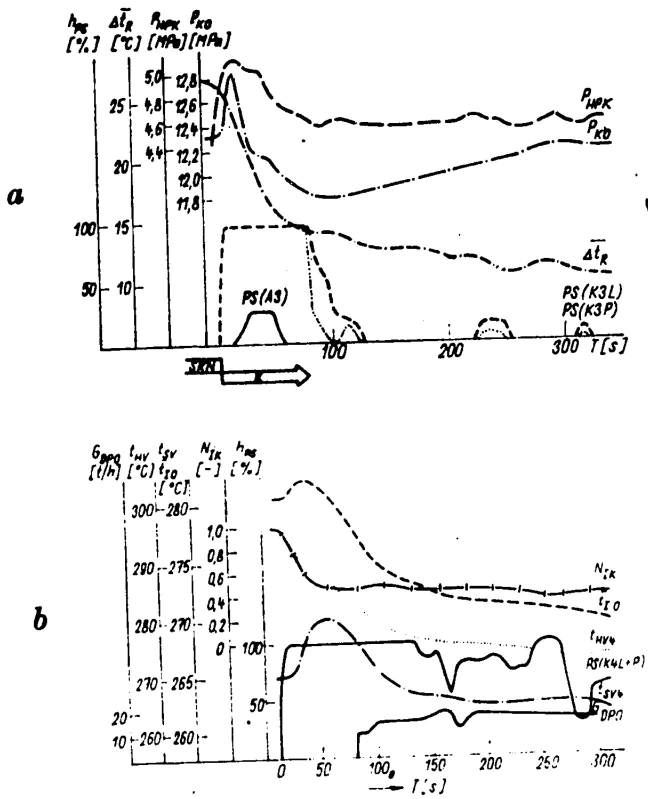
Fig. 10a, b. Main circulating pump No 5 out of operation, N_R = 100 percent, Unit 2.



Obr. 11a, b, c. Odstavenie TG 22 zatvorením RZV. N_R = 100 %, 2. blok

Fig. 11a, b, c. Stopping of turbogenerator No 22 by closing RZV valve. N_R = 1005, Unit 2.

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000400060013-7



Obr. 12a, b. Zregulovanie TG 21 a TG 22 na vlastnú spotrebu. N_r = 100 %, 2. blok

Fig. 12a, b. Regulation of turbogenerators 21 and 22 for in-house power supply. N_R = 100 percent, Unit 2.

List of Abbreviations (continued)

N_G	Turbogenerator output
P_{KO}	Pressure in compensator
P_{HPK}	Pressure in main steam collector
P_{IO}	Pressure in primary circuit*
ΔP_R	Temperature drop in reactor*

Q_i	Flow in i-th loop
t_{HV}	Temperature in hot leg
t_{SV}	Temperature in cold leg
t_{PKO}	Steam temperature in volume compensator
$\bar{t}_{IO}$	Average coolant temperature in primary circuit
$\Delta \bar{t}_R$	Average coolant temperature in reactor
T_{ef}	Reactor operating time in effective days
ΔP_i	Pressure drop in i-th loop
$d\rho/\rho t_{IO}$	Temperature coefficient of reactivity
$d\rho/d P_{IO}$	Pressure coefficient of reactivity

Operating regimes of reactor power regulator:

R: regulation mode from pressure in emergency control assembly

SRN: sentry regulating mode

SRS: unit output stabilization regulating mode.

BIBLIOGRAPHY

1. Programma fizicheskogo puska AEV V-1 "Bohunice" [Physical Startup Program for V-1 Nuclear Power Station in Bohunice]. Contract No 39 046 of 14 May 1976. Annex No 2, b, 2.1.7 [in Russian].

2. Programma energetichesogo puska I. bloka V-1 Buhinice [Power Production Startup Program for Unit 1 of Bohunice V-1 Power Station]. Congract No 39 046 of 14 May 1976. Annex No 2, b, 2.1.9 [in Russian].

3. Mjasnikov, A., and Spalek, J. BIPR-EC--Verze programu BIPR-5 pro pocitac EC-1040 [The BIPR-EC Version of the BIPR-5 Program, for the EC-1040 Computer]. UJV Rez, 1978.

4. Ferencei, K; Kruzik, F.; Mjasnikov, A.; and Spalek, J. Vysledky neutronova-fizikalnych vypoctov pre fizilakny spustanie AE V-1 [Results of Neutron-Physical Calculations for Physical Startup of the V-1 Power Station]. VUJE, Jaslovske Bohunice, 1978.

5. Rohar, S.; Sarvaic, I; Liptak, P.; and Petenyi, V. Vysledky vyhodnotenia experimentov programu fizikalneho spustania 1. bloku elektrarne V-1 [Results of Evaluation of Experiments in the Physical Startup Program for Unit 1 of the V-1 Power Station]. VUJE Report No 8/79, 1979.

6. Rohar, S.; Sarvaic, I.; Liptak, P.; and Petenyi, V. Vysledky vyhodnotenia experimentov programu fizikalneho spustania 2. bloku elektrarne V-1 [Results of Evaluation of the Experiments in the Physical Startup Program for Unit 2 of the V-1 Power Station]. VUJE Report No 2/180, 1980.

7. Adryanov, G. et al. Obzor rezul'tatov fizicheskikh issledovaniy aktivnykh zon reaktorov VVER-440 na perio' fizicheskogo puska [A Survey of the Results of Physical Tests on the Cores of VVER-440 Reactors in the Physical Startup Period]. Moscow, IAE [Institute of Atomic Energy] imeni Kurchatov, 1976 [in Russian].

8. Bardos, J. Vyuziti rozpytlu hmotnosti izotopickeho obohaceni jaderneho paliva k optimalizace provozu VVER--popis programu FLOP [Use of the Mass Dispersion of Isotopic Enrichment of Nuclear Fuel to Otimize the Operation of VVER Reactors--A Description of the FLOP Program]. UJV Rez, 1980.

9. Petenyi, V. Meranie vykonoveho koeficienta reaktivity na roznykh vykonovykh hladinakh [Measu-ement of the Power Coefficient of Reactivity at Various Power Levels]. VUJE Report No 11/79, 1979.

10. Ricany, J. et al. Vyhodnotenie experimentov energetickehe spustania 1. bloku AE V-1 [Evaluation of the Power Production Startup Experiemnts on Unit 1 of the V-1 Power Station]. VUJE Report No 23/79, 1979.

11. Ricany, J. et al. Vyhodnotenie experimentov energetickeho spustania 2. bloku AE V-1 [Evaluation of the Power Production Startup Experiments on Unit 2 of the V-1 Nuclear Power Station]. VUJE Report No 90/80, 1980.

8480
CSO: 5100/3019

V-1 OPERATING RESULTS DESCRIBED

Prague JADRENA ENERGIE in Slovak No 4, Apr 81 pp 154-157

[Article by Milan Kozak, Viliam Ziman, Juraj Kmosena and Oto Kopal, Atomove elektrarny [Nuclear Power Stations] Bohunice, and Zdeno Hudec, Slovenske energeticke podniky [Slovak Power Production Plants], Bratislava: "Results and Experience From Operation of the V-1 Power Station"]

[Text] The beginning of test operation of Units 1 and 2 of the V-1 power station in Jaslovske Bohunice produced considerable benefits for the Czechoslovak power system. The two units had produced a total of 6,686,000 MWh as of 31 December 1980, while Unit 1 had produced 2,474,000 NWh in the previous year. The utilization coefficient of the output of this unit was 0.7, which is in agreement with experience with power stations.

1. Main Data on Operation

1.1 The first unit of the V-1 power station was put into test operation on 31 March 1979 after successful physical and power-production startup and 72-hour trial operation at the nominal paremeters. The first run amounted to 349.6 effective days (without use of the power effect), compared with the calculated figure of 320 effective days.

During the first run, the electrical energy output was 3,272,589 MWh and the amount of energy delivered to the power system was 2,972,473 MWh. The maximum half-hour output at the generator terminals was 426 MWe. The operating results during the first run are comparable to results achieved in equivalent units of nuclear power stations abroad.

On 10 May 1980 the first unit was stopped for refueling and performance of guarantee reviews and repairs. Operation was resumed in July 1980; after a number of repairs, primarily on the secondary section, it operated with considerably higher power production economy.

1.2 On 26 May 1980 the second unit of the V-1 power station went into operation. A feature of this block was that its startup and trial operation involved considerably better organization and higher-quality operation. These resulted primarily from the following circumstances:

--the shortcomings which occurred in Unit 1 during startup and test operation were eliminated in Unit 2 before these steps were carried out;

--the operation personnel had acquired valuable experience on Unit 1 and made thorough use of it.

The improvement in operation on Unit 2 compared with Unit 1 is shown by comparison of the following indicators for the first 5 months of operation:

Indicator	Unit 1	Unit 2	Difference between Units 1 and 2
1. Output of electrical energy (MWh)	868,074	1,117,091	+249,017
2. Electrical energy delivered (MWh)	765,920	1,015,888	+249,968
3. In-house consumption of electrical energy for power production (%)			
4. Readiness factor of unit	0.842	0.874	0.032
5. Gross efficiency of unit (%)	27.61	29.16	1.55

Operating Experience in Electrical Energy Production

2.1. Economic Results of Operation

The 6,686,000 MWh of electricity produced by the V-1 as of 31 December 1980 would have required about 8 million tons of brown coal in a conventional power station.

Among the basic data on operating economics are the following:

--the gross efficiency of the units was 29 percent and the net efficiency 26.5 percent;

--the readiness factor was 0.77 for Unit 1 and 0.88 for Unit 2;

--the specific nuclear fuel consumption for electrical energy production was 12.6 GJ/MWh in Unit 1 (compared with a 1980 plan figure of 12.89) and 12.35 GJ/MWh in Unit 2 (compared with a 1980 plan figure of 13.9).

These data too may be considered successful in comparison with equivalent data for other units.

2.2. Factors Influencing Operating Economics

The main task of the operating personnel was and is to assure reliable, safe, economical operation of the units. The main problems in operating economics resulted from the following factors:

a. Insufficient cooling in the cooling towers decreased these units' output by about 5 MW (the cooling towers fall about 2° short of the planned figures).

b. Failure to achieve nominal reactor power with an electrical system frequency lower than 50 Hz (a 1-percent decrease in frequency means a decrease of about 4 MWe in the power at the generator terminals).

c. Scale buildup on heat exchange surfaces on the coolant-water sides of the turbine condensers was a considerable factor lowering the electrical output of the units (see Fig. 1).

In 1979 and 1980, between cleanings of the turbine condensers, the following average rates of decrease of the electrical output of the Unit 1 as a result of scale buildup on the condensers were recorded:

March-June 1979	0.40 MW/day
July-August 1979	0.43 MW/day
September-December 1979	0.58 MW/day

Average values:

March-December 1979	0.48 MW/day
January-May 1980	0.38 MW/day
August-September 1980	0.13 MW/day

It can be seen from these figures that between January and May 1980 (before the beginning of guarantee reviews of Unit 1) it was possible to decrease the negative effect of scale accumulation on the condensers by a factor of 1.24 compared with 1979, while in August-September 1980 (after the guarantee review) the improvement over 1979 was a factor of 3.52. This led to a considerable increase in operating economy for unit 2.

Now, when equipment for continuous cleaning of the turbine condensers has been installed on all turbines, we can gain an idea of the contribution this factor makes to operating economy from the following data:

--on 27 October 1980, after running-up of turbogenerator 11 with the equipment installed but not yet put into operation, the "end temperature difference in the condenser" (i.e. the difference between the temperature of the condensate leaving the condenser and the temperature of the cooling water coming from the condenser) Δt was 11°C;

--on 28 October 1980, Δt was 7.3° C after about 1 hour of operation of the equipment;

--on 29 October 1980, Δt was 5.9° C after about 3 hours of operation of the equipment. This difference has steadily decreased in subsequent operation.

--on 9 December 1980, Δt was 4.8° C for turbogenerator 11. In December 1980 it varied between 4.1° and 5° C for all turbogenerators.

Another factor leading to power losses was leakage in the turbine vacuum system. The shortcomings found were steadily corrected.

Among other improvements we may cite additional installation of siphons in the lines carrying the steam-air mixture from the condensers to the vacuum pumps, and adjustment of the turbine cleaning system. These modifications made it possible to cut the vacuum drop in the turbines in half.

2.3. Measurements for Increased Operating Economy

During test operation of the units, many test, reference and guarantee measurements were made after April 1979. The aim of these measurements was to check the planned equipment parameters at the beginning of permanent operation (static characteristics of turbogenerator regulation, primary circuit measurements, noise measurements, insulation surface temperature measurements and the like).

Below we give a more detailed description of the guarantee measurements on process equipment critical to operating economics.

2.3.1. Guarantee Measurements on the Turbosets of Units 1 and 2

The supplier guarantees the following:

a. Turbine set output of 214 + 6 MW according to the technical report of the performance plan, main generator output of 214 MWe, auxiliary generator output of 6 MWe, combined generator output of 220 MWe, under the following conditions:

--purely condensation operation, with heating of its own condensate,

--total coolant flow through the condenser equal to 35,000 m^3/hr,

--coolant water temperature 20° C,

--cos φ for main generator equal to 0.85;

--cos φ for in-house power supply generator equal to 0.8.

b. Specific heat consumption equal to 11,388 GJ/MWh in accordance with technical report of performance plan. This consumption level allows for a tolerance of 1.5 percent in addition to measurement tolerances specified in Czechoslovak State Standard 08 0070, under nominal steam conditions before the high-pressure RZV [expansion unknown].

Before guarantee measurements were made on turbogenerators 11 and 12 it was necessary to make use of the stoppage of the turbosets to inspect the equipment and clean the condensers as specified in the documentation received. The measuring instruments and measuring diaphragms used for guarantee measurements were installed, and measurements were made according to specifications. The voltages across the voltage and current transformers were measured and the specialist added certifications of the transformers used for the guarantee measurements.

During guarantee measurements on the turbogenerators of Unit 1, the condition of the two turbosets was as follows:

--The turbosystems had already been in operation for 15 months after introduction of the first steam into the turbines.

--The water-side heat exchange surfaces of the condenser had considerable scale accumulations.

--The vacuum system was not tight (the vacuum drop for turbogenerator 11 was 1707 Pa/min and that for turbogenerator 12 was 1853 Pa/min).

--The pressure system in the secondary circuit was not tight. The irreversible mass leakage was 12.76 tons/hour.

Since the guarantee measurements on turbogenerators 11 and 12 and on turbogenerators 21 and 22 were performed under conditions which deviated from those agreed upon, the results were corrected to the agreed-upon conditions for validity of the guarantee.

The main results obtained were as follows:

Guarantee measurements on turbogenerators 11 and 12, performed 23 November 1979:

--The corrected measurement of specific heat consumption was 11.507 GJ/MWh, 1.05 percent over the guaranteed value (11.388 GJ/MWh). However, this value was within the $\pm$1.95 percent tolerance for measured consumption.

Guarantee measurements on turbogenerators 21 and 22, performed 30 May 1980:

--Corrected measured specific heat consumption equal to 11.282 GJ/MWh, 0.934 percent below the guaranteed figure (11.388 GJ/MWh). This is within the $\pm$ 1.25 percent measurement tolerance.

--Corrected measured power during phasing-in of turbogenerator 21 equal to 235.22 MWe, 1.92 percent higher than the value called for in Czechoslovak State Standard 08 0030, with a measurement tolerance of $\pm$0.75 percent.

--The net thermal efficiency of turbogenerators 21 and 22 was 29.65 percent (31.6 MWe for in-plant consumption according to Landis meter).

It should be noted that the effect of warmer cooling water (the intake temperature of the cooling water was 26.67° C for turbogenerator 21 and 26.37° C for turbogenerator 22 and the outlet cooling water temperatures were 38.17° and 38.73° C respectively) had a negative effect on the measured output amounting to 13.552 MWe compared with the output at a nominal cooling water temperature of 20° C.

2.3.2. Gurantee Measurements on Cooling Tower No 2

The guaranteed cooling tower design parameters are:

--quality of heat removed Q = 1624 GJ/hr,

--cooling water mass flow G = 36,250 tons/hr,

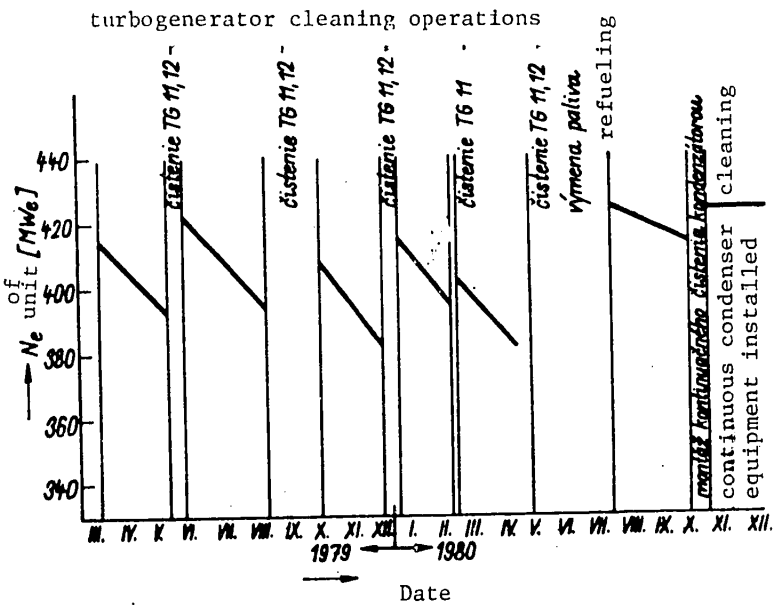


Fig. 1. Drop in electrical output of Unit 1 of the V-1 power station, corrected to cooling water temperature of 20° C, showing the effect of fouling of the tubes in the main condensers during the period from March 1979 to December 1980.

--temperature of heated water t_1 = 32.7° C,

--temperature drop t = 10.7° C,

--temperature of cooled water t_2= 22° C,

--base conditions for ambient air, t_{s1} = 15° C, ϕ = 70 percent,

--wind speed v = 2 m/sec.

Different hydraulic and thermal load conditions are allowed for by a set by correction curves.

The flow volume of coolant water was measured in the outflow channel from tower No 2 using carriers equipped with flow meters, which were vertically displaced along the measured vertical speed profile at a rate of 2 cm/sec.

The guarantee measurements indicate that the towers are falling short of the initial planned parameters given above by 2.1° to 1.8° C depending on the nominal coolant flow volume selected.

When the cooling effect was evaluated following additional corrections it was found, for example, that for a cooling water base temperature t_{2z} = 24.5° C the tower would meet the guarantee figures, since (again depending on the coolant water flow volume chosen) the cooling values were 0.2° to 0.5° C better than the guarantee figures.

The following conclusions follow from the guarantee measurements on the cooling towers:

1. The inadequately dimensioned cooling system is failing to maintain the guaranteed cooling water temperatures.

2. The cooling effect is highly sensitive to wind action, and cooling water is removed through the high intake openings by the wind.

3. Equipment Malfunctions.

During operation of the units, failures which by and large were typical of power station equipment in the initial stage of operation occurred. Some of these failures decreased the power output of the unit.

The individual circuits of the power station typically showed the following malfunctions:

Primary circuit

--failures in main circulating pump power supply cable connections;

Secondary circuit;

--leakage in steam piping,

--leakage in high pressure heaters in the regeneration system,

--incorrect operation pump shutoff devices in the regeneration system;

Other:

--conflict between the ARM reactor power regulator and the TVER turbine output regulator,

--nonselective switching-out of electrical switchgear for in-plant power supply,

--actuation of protective devices during starting of 6 kV electric motors.

Other malfunctions included the effect of limited operating personnel experience.

All of the malfunctions and defects were immediately analyzed and the measures indicated were taken without delay. The decrease in the number of personnel-caused malfunctions indicates that the operating personnel were acquiring good operating experience.

4. Refueling of Unit 1

The first refueling of Unit 1 was carried out between 10 May and 23 July 1980 in combination with guarantee reviews and prescribed tests. The work proceeded in accordance with documentation developed for the purpose. A total of 36 work programs, 25 time schedules and 9 organizational measures were drafted. In addition to this general documentation, the maintenance division drew up a separate document for each action, including a work order, performance documentation, testing documentation and the requisite supporting documentation.

The purpose of the work done during the first refueling, other than the standard refueling and equipment review program, also included included the performance of work indicated by operating experience with Unit 1.

The progress of the work was considerably affected by the demanding process of eliminating leakage in the refueling and storage pond. For this reason, disassembly of the reactor began 21 days later than planned.

Availability of spare parts was good.

The work involved in refueling, guarantee repairs and review and testing of materials was carried out to the planned extent. The slippages which occurred in the initial period were partially made up by intensified initiative, good labor organization and increased overtime. The experience obtained will be reflected in the refueling documentation for 1980 and in subsequent refueling operations.

In addition to the specifications which are customary in every refueling of this type of nuclear power station, there arose a requirement to empty the emergency boron tank. Procedures were worked out and a backup method of making up losses and of assuring cooling during coolant loss in the core was developed and carried out. The refueling was carried out without breaches of nuclear safety.

As regards observance of nuclear safety, the first refueling of Unit 1 involved special requirements.

To maintain general safety during the system of maintenance work, a system of so-called "S" orders was introduced and proved effective. This system unambiguously defines the method of removing equipment for repair, the work procedures for repair and maintenance, the personnel requirements, and responsibility.

The work carried out during the first refueling of Unit 1 did a great deal toward attainment of the planned characteristics.

5. Conclusion

To date, operation of the two units of the V-1 power station has successfully met plan assignments for electrical energy production.

The most important results are considered to be the number of kilowatt-hours produced for the national economy and the valuable operating experience obtained, which will be fully utilized in subsequent operation.

However, it is clear that operating results cannot be evaluated solely in terms of the number of kilowatt-hours produced. A comparison of the characteristic statistical data for Units 1 and 2 indicates where there is unused potential, where there are failings and where further effort should be directed in order to increase operating reliability and quality. The following are considered to be essential tasks for the next period of operation:

a. Further improvement of the system for increasing the qualifications of operating and technical personnel, i.e. further improvement of the special, theoretical and practical proficiency and readiness of the personnel in direct connection with the level of discipline.

b. From the social point of view, it is clear that an effort must be made to decrease specific fuel consumption.

c. Findings already obtained from the operation of the two units have provided new, more precise data for updating the operating and safety documentation. In the next stage it will be necessary to develop standardized documentation for equipment maintenance.

d. It will be necessary for the operator, designer and performing organizations and subdivisions to make joint efforts to eliminate causes of the main malfunctions and their negative effects on operating reliability and economy.

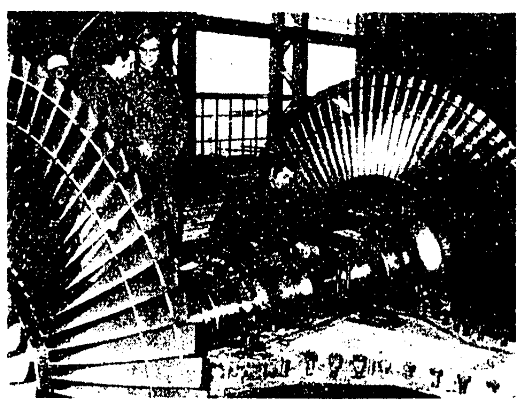


Fig. 2. Installation and test work on rotor parts of 220 MW turbine.

8480
CSO: 5100/3019

ACTIVITIES OF STATE NUCLEAR SAFETY OVERSIGHT OFFICE DESCRIBED

Prague JADERNA ENERGIE in Czech No 4, Apr 81 pp 158-160

[Article by Jiri Beranek et al., CSKAE [Czechoslovak Atomic Energy Commission] Prague: "Activities of the State Nuclear Safety Oversight Office, SCKAE, in the Construction and Operation of the V-1 Nuclear Power Station"]

[Text] This article presents information on legislative provisions for the activity of the State Nuclear Safety Oversight Office, CSKAE, and gives a rather detailed description of the approval process for the physical and power production startup of the V-1 power station.

By Czechoslovak Government Presidium Decree No 195 of 1 September 1977, the Czechoslovak Atomic Commission [CSKAE] was empowered to conduct state oversight over nuclear safety as a socially necessary preventive activity to assure that nuclear power installations could be designed and built without undesirable radiation rist to the operating personnel, the public and the environment. In view of the importance of nuclear safety and the social importance of this problem, the legal basis for state oversight of nuclear safety has now been developed on the basis of decisions by the CSSR Government Presidium; their purpose is to lay out in comprehensive form the tasks, standing and competence of the state oversight office, including the necessary authorization for the performance of its oversight activities. Previously, in the absence of this basic legal provision, the function of the State Nuclear Safety Oversight Office, CSKAE, was legislatively mandated and developed step by step over a number of years in keeping with the development and requirements of the Czechoslovak program. The activities generally have been legislatively mandated during the drafting or updating of basic legal instruments, for example in the updating of construction law No 50 in 1976. Some further state oversight functions were legally mandated in the form of government decrees (Government Presidium Decrees Nos 195/77 and 156/79).

The construction, commissioning and first successful period of operation of Units 1 and 2 of the V-1 nuclear power station mark a significant milestone in the implementation of an extensive Czechoslovak nuclear power program. It is an especially significant milestone in view of the successful beginning of construction in this program, since this work has all the characteristics of industrial construction. The industrial nature of the construction and the use of the flow-through construction method are the decisive elements for the organization of construction and of the relationships between all its participants, including all oversight bodies, which, as indispensable participants in construction and operation must also adapt to these quantitatively and qualitatively new conditions.

The industrial nature of this construction is governed by the following main factors:

--nuclear power stations are undertaken in the form of standard plans for proven units, and include nuclear safety concepts;

--the individual production stages of the series with 440 MW unit power all stem from the same basic design;

--the series of VVER 440 nuclear power stations in the Czechoslovak program is so extensive that there is a direct need to develop an optimal (standard) approach both in organizing construction and in preparing for operation, as well as in state oversight activity.

On the basis of an analysis of these circumstances, the State Nuclear Safety Oversight Office orients its activity in the following directions:

--as regards the nuclear safety design concepts embodied in the plans, it monitors the completeness of information required for preparation of the Czechoslovak program, and sees to it that the plan can be implemented effectively and that no basic changes are allowed without the agreement of the designers,

--for the activities carried out on Czechoslovak territory (selection of a construction site, construction, commissioning and operation), it must provide the legislative base, a viable approval and inspection body, and an effective feedback mechanism.

As empowered by the laws specifying its jurisdiction, it has prepared and issued universally binding legal documents on the basic requirements for nuclear safety in the various stages of construction of nuclear installations. These are:

--CSKAE Order No 2 on assuring nuclear safety in the design, licensing and construction of projects involving nuclear power installations (1978);

--CSKAE Order No 4 on general criteria for assurance of nuclear safety in the siting of projects involving nuclear power installations (1979);

--CSKAE Order No 5 on assuring nuclear safety-related quality of selected equipment in the nuclear power industry (1979);

--CSKAE Order No 6 on assuring nuclear safety in the startup and operation of nuclear power installations (1980).

The preparation of these regulations was based in particular on Soviet regulations and on Czechoslovak experience in the construction and operation of nuclear power facilities, especially the V-1, which naturally preceded these regulations and was a stimulus for their preparation.

This basic series of universally binding legal instruments for assurance of nuclear safety designates relations between the state oversight office and the other participants in the Czechoslovak nuclear program as well as technical requirements and procedures, and has had a particularly favorable effect in the case of Unit 2 of the V-1 station. Experience and needs to date indicate that certain requirements established by the state oversight office will need to be worked out in more detail in the form of directives or instructions. Some of these directives are now being prepared (more detailed instructions on the drafting and content of safety reports, limits and specifications, the scope of ecological studies, specifications for various quality assurance programs).

The State Nuclear Safety Oversight Office's authorization to issue approval for the various stages of construction and operation of nuclear power facilities is contained in construction law No 50 of 1976 and its implementation notices Nos 83 and 85. The following basic stages are established: site decisions or decisions on the safety zone, and construction licensing and warranty inspection decisions (i.e. permanent operation). These approvals are issued after presentation of applications supported by a safety report (acceptance, preliminary, pre-operation), and may be made contingent on fulfillment of conditions with set deadlines.

On the basis of regulations in force, the State Nuclear Safety Oversight Office gives its authorization after presentation of an application and the required documentation. Requirements regarding the drafting and content of safety reports are laid down by specific CSKAE directives.

In addition, the oversight office also gives partial authorizations on the basis of authority granted by Government Presidium Decree No 156 of 1979 for the physical and power-production startup programs, for loading of the nuclear fuel into the core, for the beginning of the various stages of physical and power-production startup, for trail and permanent operation, for changes in documentation affecting nuclear safety, and for methods of transportation and storage of fresh and spent fuel.

Thus far the V-1 power station is the most complete facility to which all of the oversight office's activities have applied.

In terms of nuclear safety, the commissioning of a nuclear power station is among the most important stages in its entire existence. This involves a relatively short time span of several months, during which it is, however, necessary to check all neutron-physical, thermal, hydraulic, regulating and other characteristics of the completed project and to demonstrate the fulfillment of all requirements and conditions contained in the plan and in the pre-operation safety reports and other documentation. An extremely important requirement in this stage is painstaking planning of experiments and adherence to all safety requirements during their performance. The main risk during startup results from the fact that in the initial stage the reactor has the largest reserve of reactivity, the highest incidence of malfunctions and failures is expected in most equipment, and during this period the operating personnel are first acquainting themselves with the new equipment in operation. Accordingly, the startup period requires the most intensive activity on the part of the oversight office.

The main requirement for issuance of an authorization for operation of a nuclear facility is the presentation of complete, substantive documentation in the pre-operation safety report. In the case of the V-1 power station, this report was presented to the State Nuclear Safety Oversight Office, CSKAE, in July 1978 and underwent a number of expert evaluations. The conclusions were discussed by the Nuclear Safety Council of CSKAE and by a full CSKAE session. The individual stages requiring authorization during the commissioning process were established as follows:

1. physical startup (including loading of fuel),

2. power production startup,

3. trial operation,

4. permanent operation.

An essential requirement for advance to the next stage was evaluation of readiness for it, an assessment of the preceding stage, and presentation of the requisite "Limits and Specifications."

Physical startup of Unit 1 of the V-1 power station was begun after performance of the required prepatory startup work (functional tests, pressure test, first review, hot tests, second review).

The state oversight office established specific requirements for this stage and made issuance of its approval for introduction of the fuel and for physical startup contingent upon their fulfillment. The required documentation consisted of the following:

1. Reports on system readiness tests during the second review (reactor, protection and regulating system, reactor monitoring and measuring equipment, startup equipment, equipment for introduction and storage of fuel, radiation protection and monitoring systems, boric acid preparation system, ventilation systems, electrical power supply systems, communications systems).

2. Procedure and time schedule for loading the fuel.

3. Instructions for assuring nuclear safety during loading of fuel.

4. Instructions for assuring nuclear safety during storage of fuel.

5. The physical startup program (attainment of criticality, list of physical experiments and their sequence and procedures, and evaluation of the experiments).

6. Instructions for assuring nuclear safety during physical startup.

7. Readiness of operating personnel and interface with physical startup group.

8. Operating regulations needed for physical startup.

9. Set of documentation on loading of fuel and physical startup.

10. Program for monitoring of dosimetric measurements during physical startup.

11. Emergency plan for power station employees.

After these requirements were met, authorization was issued for loading of the core, which was completed on 13 November 1978 in the presence of a CSKAE inspector. After detailed testing of equipment readiness, a special working group led by CSKAE gave CSKAE's approval for physical startup on 23 November 1978, contingent on the meeting of further conditions. The physical startup-program for Unit 1 of the V-1 power station was concluded on 7 December 1978.

After fulfillment and evaluation of the planned experiments included in the physical startup, preparations began for power-production startup. The documentation required by CSKAE for authorization to begin power production startup included:

1. Evaluation of stage I (introduction of fuel and physical startup) and conclusions drawn for the purpose of power-production startup.

2. The power production-startup program (performance procedures, expected numerical values, organization).

3. Limits and specifications for power-production startup (or substitute documentation).

4. Reports on readiness and acceptance for power production operations of all standard systems, equipment and facilities of the power station.

5. Operating regulations for the equipment of the V-1 station.

6. Equipment maintenance regulations.

7. Worker readiness for power production startup, and interface with startup group.

8. Readiness of emergency plan for the public.

After evaluating the current state of affairs on the basis of inspections, on 13 December 1978 the State Nuclear Safety Oversight Office, CSKAE, gave its authorization for the commencement of power-production startup with a number of additional conditions whose fulfillment it required by specified dates, or before attainment of specific power levels, depending on the importance or technical performability of the conditions. This authorization also included requirements for evaluation of the results of power-production startup after 35 percent of rated power was achieved. CSKAE made the issuance of its approval to proceed to higher power levels contingent on approval of the evaluations for this stage. By this approach the office not only kept constructively informed of the requirements for smooth performance of the power production startup, but also set deadlines for the meeting of requirements which were important for nuclear safety before higher power levels could be reached.

The office devoted particular attention to and laid particular stress on measurement and regulation systems and protective and shutoff mechanisms, which were affected by a considerable number of conditions and requirements, including the keeping of records on defects in these systems, and ultimately the performance of several specialized inspections including experts in this field. The subsequent course of the startup process showed that the stress laid on this area was fully justified.

The state oversight office used a similar approach to authorization at the 55, 75, and 100 percent power levels.

The power production startup was concluded by a 72-hour operating trial at rated power and with the specified operating parameters. The full complex of tests specified in the power production startup program was carried out.

On 26 April 1979 the State Nuclear Safety Oversight Office, CSKAE, gave its authorization for the beginning of trial operation of Unit 1 of the V-1 power station. The overall positive tendency of trial operation in terms of nuclear safety justified the issuance of the authorization to put Unit 1 into permanent operation, as requested by the operator on 23 January 1980.

In 1979, V-1 Unit 2 was undergoing final installation work and gradual preparation for startup. Even in these stages it was evident that the positive experience which all construction participants had obtained in working on Unit 1 was making itself felt. Incoming and pre-operation tests were also performed more rapidly than in the case of Unit 1.

Even before the conclusion of the preparatory stages for startup of Unit 2, the activity of the State Nuclear Safety Oversight Office was concentrated on the fulfillment of the improved programs for incoming tests of selected equipment, testing of equipment and systems readiness, and performance of the programs of tests in the individual stages of startup of the unit, and subsequently on running evaluation of the results obtained in physical and power production startup, comment on and approval of the relevant documentation, designation of specific steps to be taken to eliminate malfunctions connected with nuclear safety, evaluation of technical designs involving various changes and modifications in the plans for individual systems and equipment (about 250 were developed for the V-1 power station) and checking the readiness of operation personnel. In view of the requirement for precise evaluation of the results obtained in the various experiments, the State Nuclear Safety Oversight Office required the development of success criteria for the individual experiments. This made possible an objective and expeditious evaluation of results in all startup stages.

There proved to be a sufficient reserve of time for the beginning of startup, particularly as a result of considerably greater equipment readiness and better adjustment, which ultimately led to a smoother physical and power-production startup.

For example, there was time for tests of the tightness of the primary circuit compartments. Similar tests were made on Unit 1 even during the stoppage for refueling (fulfillment of one of the oversight office's conditions issued when Unit 1 went into permanent operation).

Experience fully justified CSKAE's requirement that all equipment be ready as early as the physical startup stage, and as a result the physical and power-production startup processes took less time than for Unit 1 because of the higher degree of equipment readiness.

After evaluation of the documentation presented for Unit 2 of the V-1 station, and of the readiness of equipment and personnel and evaluation of the preceding stages, CSKAE issued the following authorizations:

a. Authorization for the program of loading of fuel into the core of Unit 2 of the V-1 and for the physical startup program, on 22 January 1980.

b. Authorization for actual loading nuclear fuel into the core of Unit 2, on 21 February 1980.

c. Approval for the power-production startup program for Unit 2, on 7 March 1980.

d. Approval for commencement of physical startup of Unit 2, on 7 March 1980.

e. Approval for commencement of power-production startup of Unit 2, on 25 March 1980.

f. Approval for commencement of trial operation of Unit 2, on 9 May 1980.

As in the case of Unit 1, most of the authorizations included supplementary conditions on whose fulfillment the validity of the state oversight office's authorization was contingent.

The approval process for a nuclear power installation is a demanding, continual process which begins with the selection of a site and ends with the final removal of the facility from operation, and which involves a weighing of the requirements and interests of the individual partners involved in it. Rapid and effective performance requires mutual trust and respect, particularly on the part of the two partners, i.e. the monitoring body (the State Nuclear Safety Oversight Office) and the applicants (before the beginning of permanent operation, the builder and investor, and subsequently the operator). One of the main conditions is good, continuous exchange of information.

As the Czechoslovak nuclear program has developed, the requirements regarding the activity of the State Nuclear Safety Oversight Office have been steadily expanded and deepened. The quality of its activity has been improved, particularly since the creation of the post of permanent inspector on-site in Jaslovske Bohunice; this officer's activity began in July 1979. The use of a permanent inspector has justified itself especially well, both for the state oversight office and for its partners, thanks to increased expeditiousness in inspection and running provision of information.

There has been a fundamental imporvement in the quality of monitoring activity, which has been economically beneficial.

The experience with the commissioning of the V-1 power station indicates that the basic contingent of experienced workers has been created and that with Soviet assistance they have mastered the complex and demanding task of building the V-1 power station and putting it into reliable and safe operation. In this complex process, the State Nuclear Safety Oversight Office, CSKAE, was an effective and involved participant in construction, and its positive contribution has been recognized.

8480
CSO: 5100/3019

WORK OF SLOVAK LABOR SAFETY OFFICE IN V-1 PROJECT DESCRIBED

Prague JADERNA ENERGIE in Slovak No 4, Apr 81 pp 161-162

[Article by Augustin Simoncic, SUBP [Slovak Labor Safety Office], Bratislava: "Participation of the Slovak Labor Safety Office in the Construction and Operation of the V-1 Power Station"]

[Text] The oversight activity of the Slovak Labor Safety Office in the construction and operation of the V-1 nuclear power station and the prospects for more intensive oversight over the safety of nuclear power equipment in the construction of future nuclear power station in Czechoslovakia are described.

The Slovak Labor Safety Office (SUBP) performs state specialized oversight (SOD) over labor safety, technical equipment safety and observance of the power industry working conditions established in accordance with Law No 174/1968 (Code) and the associated implementation regulations.

In view of the importance of the new technical and social problems and the potential risk involved in nuclear power, the highest state and political bodies in Czechoslovakia are devoting particular attention on it. In its 1977 session, the SSR Government Presidium adopted Decree No 319 (pursuant to CSSR Government Presidium Decree No 195 (1977) on state specialized oversight in the nuclear power field.

This SSR government decree instructed the head of SUBP to:

--issue compulsory rulings based on the results of its oversight,

--create a special group of experts for oversight purposes,

--issue regulations for assurance of technical safety, particularly of pressure components.

By its order of 8 August 1980 (pursuant to paragraph 5, section 1, article h of Law No 174/1968 (Code)) assigning the performance of state specialized oversight over nuclear power facilities, SUBP took on the performance of state specialized oversight tasks in the planning, production, installation, construction and operation of nuclear power facilities, as specified in paragraph 4 of Law No 174/1968 (Code) and in accordance with SSR Government Decree No 319/1977 on state technical oversight in the nuclear power field.

In accordance with this law on state specialized oversight of labor safety, technical equipment and prescribed working conditions, and particularly in accordance with the SSR government decree mentioned, SUBP's component elements greatly intensified state specialized oversight over the production, installation and operation of components and operating sets of nuclear power equipment of the first Czechoslovak VVER-type nuclear power station. The main principle of this special intensification of state specialized oversight over nuclear power equipment was the performance of industrial functions in which it monitored the entire process from the investment concept to the decommissioning of nuclear power equipment to see that the design, performing and operating organizations observed the conditions stemming from extremely demanding qualitative requirements regarding safety and operating reliability of nuclear power equipment.

During this period consultations by construction participants with state specialized oversight personnel, even during development of the preparatory and performance documentation (in the early 1970's), as well as evaluation of technical documentation developed at the overall planning design level, preceded direct oversight over the construction and installation of entire units of nuclear power production equipment.

As time passed, the requirements for work by state specialized oversight bodies grew continually as both the amount of oversight work and the demands on the special capabilities of oversight workers increased. It became necessary to arrange their work so that during installation they were included in the working groups which are charged with solving problems arising in particular from discrepancies or differences between the safety requirements of existing Czechoslovak standards and regulations and the ready-manufactured imported equipment produced according to regulations in force in the producing country. SUBP's oversight activity was based on:

--intergovernmental agreements on cooperation in the construction of nuclear power stations in Czechoslovakia which had been concluded between the CSSR and USSR governments,

--delivery contracts concluded between the Czechoslovak purchaser and the foreign supplier in accordance with the intergovernmental agreement,

--USSR regulations concerning pressure components of the primary circuit and other selected pressure components,

--Czechoslovak standards and regulations in force.

Starting in the middle of 1978 the question of safety and operating reliability of imported technical equipment used (i.e. hoisting equipment) or installed during the construction of the first unit of the V-1 power station required permanent presence on-site of state specialized oversight representatives. In the various working groups, these staff members took a direct and active part in solving the technical problems associated with this equipment, proposing alternative methods of solving problems which enabled the builder or supplier organization to chose the method which was most suitable in terms of installation capacities, expenditures and adherence to the construction schedule, while simultaneously meeting the safely and operating reliability requirements for the equipment.

A part of the intensified state specialized oversight was the oversight bodies' work to assure that regulations and additional technical conditions for construction and installation of the various types of technical equipment and other selected process equipment and facilities were observed. The state specialized oversight bodies also participated in evaluating applications for exceptions from Czechoslovak state standards and in evaluating proposals for design modifications on imported equipment which did not fully meet the safety requirements of Czechoslovak regulations and for which exceptions could not be granted.

Based on the situation in the production and installation of technical equipment and in the construction of installations for the V-1 power stations, the state specialized oversight bodies issued compulsory rulings on the readiness of operating sets, process units and facilities in keeping with the relevant legal provisions for the purpose of safety of both designated and other process equipment. This documentation provided the essential data for overall state specialized oversight rulings for individual stages in the startup of Unit 1 of the V-1 power station.

SUBP issued rulings on the readiness of technical equipment in Unit 1 during the following stages:

--loading the reactor with nuclear fuel and physical tests of the reactor,

--power production startup of the unit,

--test operation,

--permanent operation.

During 1975, concurrently with the performance of oversight activity on Unit 1 of the V-1 power station, SUBP staff members also carried our oversight over construction and installation of operating sets, process units and installations of Unit 2. The procedure was simpler in some respects than that for Unit 1. Many problems were solved in a similar manner to that used in Unit 1, but the oversight activity was partially expanded to include oversight of labor safety and technical equipment safety in the test operation of Unit 1.

As part of their intensified oversight of technical equipment safety in the installation of process units and operating sets for Unit 2, state specialized oversight personnel focused especially on the quality of installation of all types of equipment as it affected safety. This oversight was performed pursuant to the requirements which SUBP had established for the general management of Slovenske energeticke podniky [Slovak Power Production Enterprises] Bratislava regarding the scope of documentation for authorization to commission Unit 2.

As in the case of Unit 1, SUBP also issued rulings on the readiness of process equipment for all stages of the startup of Unit 2.

The complexity of state specialized oversight over labor safety and technical equipment during the planning, construction and operation of nuclear power facilities was multiplied by the shortage of legal regulations and standards in Czechoslovakia regarding the safety of nuclear power installations. This state of affairs required intensified efforts and made greater demands on the theoretical knowledge and practical experience of state specialized oversight personnel, especially those overseeing the safety of designated technical equipment. Accordingly a considerable number of consultations were held to make it possible to apply experience and findings acquired during oversight of other important, technically demanding production units.

One of the main preconditions for this system of intensified state specialized oversight in the nuclear power field was development of the necessary legislative base. Accordingly, SUBP, in close cooperation with CUBP [Czech Labor Safety Office] performed a detailed analysis of the current state of legislation on technical safety of nuclear power facilities and other important technical equipment which assures the safety and operating reliability of the most important components of nuclear power stations units. On the basis of this analysis, the offices are currently developing the technical basis for a new legal standard which will expand the range of technical equipment covered. Under its aegis, state specialized oversight will be intensified in accordance with SSR Government Decree No 319/1977. This applies to designated technical equipment which is covered by SUBP and SBU [expansion unknown] Notices Nos 23-26/1979 (code) and SUBP Notice No 7/1979 (code), and other equipment whose safety and operating reliability directly affects the safety of the most important components of the primary circuit and of the nuclear power station as a whole. The Notice on State Specialized Oversight of Nuclear Power Station Facilities, the executive notice for Law No 174/1968 (Code), would be the new legal norm.

By 1 April 1980, SUBP had organized a department for oversight of nuclear power facilities. After it is fully staffed, its mission will be direct performance of state specialized oversight in the nuclear power field in Slovakia as part of implementation of the Czechoslovak nuclear program. It will be charged with performing intensified state specialized oversight over the pressure components of the primary circuits and certain other equipment in accordance with the Notice on State Specialized Oversight in the Nuclear Power Industry which is being prepared, and oversight of labor safety, technical equipment and the observance of established working conditions in accordance with Law No 174/1968 (Code).

On the basis of experience acquired in the construction of the V-1 power station, SUBP is now doing everything possible to intensify and improve its activities so that it will be capable of implementing fully the intensified state specialized oversight regime.

To exercise this function and to fulfill consistently SSR Government Decree No 319/1977, on the basis of its experience in the construction of the V-1 power station SUBP has organized field offices with working teams of inspectors directly on the construction sites of nuclear power stations (Jaslovske Bohunice and Mochovce).

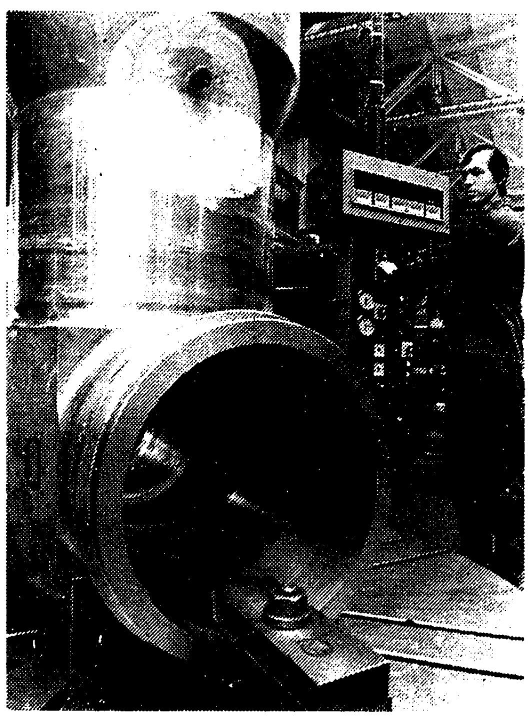
After the nuclear power equipment oversight department is fully staffed, SUBP will exercise permanent oversight over the quality of planning documentation, production, construction, and the adherence to technical specifications for equipment during its operation, as these matters affect safety. Thus state specialized oversight activity in the construction and operation of nuclear power facilities will become a permanent component of the implementation of the Czechoslovak nuclear program in Slovakia.

8480
CSO: 5100/3019

SIGMA MODRANY ENGAGES IN NUCLEAR POWER PLANT EQUIPMENT MANUFACTURE

Prague HOSPODARSKE NOVINY in Czech No 24, 12 Jun 81 p 3

[Text] One of the enterprise taking part in the design, production and installation of equipment for nuclear power stations is Sigma Modrany. Because of the increased demands imposed on the production of this equipment, Sigma has reconstructed old facilities, and during 1980 it provided new capacities for the production of nuclear power station fittings. The photograph shows the machining of a valve for the Js500 piping for a nuclear power station.



8480
CSO: 5100/3019

END